VOL. XVIII, NO. 3 JULY, 1936 Old Series Vol. XXXIV, No. 3

The Journal of Bone and Joint Surgery

THE PRESIDENT'S ADDRESS

The Rôle of Physical Therapy in Orthopaedic Surgery *

BY FREDERICK J. GAENSLEN, M.D., MILWAUKEE, WISCONSIN

Physical therapy, the oldest form of treatment of the sick and injured, should need no one to champion its cause; nor would this be necessary had not unwarranted claims for agents as yet little understood brought disfavor upon the subject as a whole. Well-informed physicians know that heat, massage, water, and exercise are still the mainstays of physical therapy and that the mysterious and high-priced devices for the administration of some of the newer agents are still largely in the experimental stage, are of limited usefulness, and are often greatly overrated. Partial truths have been magnified both by cultists, endeavoring to build up a system of the cure-all type, and by members of the profession, guilty of unwarranted optimism. Small wonder that the better element in the profession has shown a tendency to refrain even from the legitimate use of the newer agents, in order to avoid the suspicion attached to those employing these methods promiscuously and without proper attempt at evaluation.

Since the work of the orthopaedic surgeon deals very largely with the function of the locomotor apparatus, and since physical therapy ministers to a large proportion of patients with dysfunction of the locomotor apparatus, there is perhaps a closer relationship between physical therapy and orthopaedic surgery than between physical therapy and any other specialty. It therefore behooves us as a group to recognize not only the virtues but also the limitations of physical therapy, in order that this important branch of therapy may be included in our program of treatment when indicated, and also that the younger men coming under our influence may be given an opportunity to form their own opinions from observation of the use of these measures in impartial hands rather than from the sales talks of manufacturers' agents.

* Presented at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 19, 1936.

The older and simpler forms of physical therapy have been found useful from time immemorial. In this group belong rest, heat, light, massage, and exercise. Until recently some of these agents were employed largely on an empiric basis, but as our knowledge increased sound scientific principles were found to underlie their use. The difficulty with some of the newer agents is that not enough clinical evidence is available to justify them, even on an empiric basis. Our attitude toward this type may well be one of benevolent neutrality, at least until clinical evidence in sufficient volume from well-qualified, unprejudiced investigators is available, even although science may be slow in providing logical explanations.

It will be of interest to consider the various agents and to determine to what extent they are based on sound principles.

REST

The need of rest to the injured part in the case of a fracture is self-evident to allow the repair process to go on without interruption. The initial process of repair may be visualized as an attempt on the part of newly formed connective tissue and the accompanying vessels to bridge the gap between the fragments. If these attempts are constantly aborted, repair cannot take place. In the acute inflammatory process, rest is necessary to avoid dissemination of the invading organisms along fascial planes and tendon sheaths, with a breaking down of nature's barriers of defense and the exhaustion of efforts at repair. The frequent occurrence of non-union, due to insufficient fixation, and the spreading of an infection, as a result of injudicious use, may serve as clinical evidence of the value of rest in the conditions named. In infantile paralysis and in peripheral-nerve injury, the use of rest, with the involved muscles in the position of relaxation, is axiomatic. In these and many other conditions, rest is an indispensable part of the recovery program.

HEAT

It is generally accepted that heat causes relaxation of tissues, relief of muscle spasm, increased blood supply, and, consequently, improved nutrition. Goldschmidt and Light, in studying the effects of local heat on blood chemistry, found that the venous blood returning from the heated part showed diminished oxygen content, while the carbon-dioxide and lactic-acid content was increased. In other words, warmed tissues withdraw and use oxygen in greater amount, while waste products and presumably toxic material, if present, are eliminated more efficiently. That adequate blood supply favors defense against infection and promotes repair and growth of tissues is proved by abundant clinical observation. In this connection, the work of Brown and Roth on the physiological changes in blood, due to exercise and variations in environmental temperature, is interesting and enlightening. They found that normally the oxygen saturation of venous blood is 70 per cent. During exposure to cold, the number of open capillaries is decreased, the rate of flow is dimin-

ished, and the metabolism of the tissue is inhibited. The rate of exchange between the blood in the capillaries and the tissues is decreased, as evidenced by the fact that the blood entering the veins contains 75 to 80 per cent. of the saturated value. After local application of heat, the number of open capillaries is increased, the rate of flow and tissue metabolism is accelerated, and the rate of exchange between the blood and tissues rises to its optimum. As a result, the blood entering the veins contains only from 60 to 65 per cent. of its saturated value of oxygen.

MASSAGE

Massage as a therapeutic measure is universally accepted and widely employed. In treating recent injuries, following the teaching of Championnière, Mennell, and others, massage should be very light and rhythmic. If so administered, it is helpful in relieving pain and in relaxing muscle spasm, as well as spasm of vessel walls. As a consequence of this relaxation, there is a markedly increased flow of blood and lymph, with a resulting increase in local metabolic activity, conducive to tissue repair. This stimulating effect on the circulation is commonly regarded as a reflex effect, proof of which may be seen in the moving-picture film prepared by Clark and Swenson, which shows the capillary circulation in the rabbit's ear. Gentle stroking of the ear was followed by marked widening of the capillaries and a tremendously increased rate of flow. As the stroking was so light that mechanical emptying of the veins could be excluded, the reflex nature of the stimulation seems apparent. In the later stages of fractures, sprains, and other injuries in which persisting oedema obstructs venous return, deep massage, always in the direction of the venous flow, is indicated for the removal of exudate and waste products. As the veins are emptied by pressure, there is a rapid refilling from the capillary and arterial side, resulting in definite improvement of local nutrition. Preliminary heating or heating during the period of massage is of added value, as is also elevation of the part in order to secure the benefit of gravity in emptying engorged vessels.

EXERCISE

Active exercise is perhaps the most valuable of all forms of physical therapy, because it calls into play the entire neuromuscular apparatus. This apparatus consists of three distinct parts:

1. The upper and lower motor neurones and the contracting muscle cell;
2. The inhibitory mechanism providing for finely graduated, precise movement;
3. The mechanism insuring relaxation of antagonistic muscles.

Thus the voluntary effort involves function of the entire complicated mechanism, which cannot be claimed for any other form of physical therapy. Accompanying muscle contraction there is compression of the lymphatic and venous channels, while during muscular relaxation these

vessels fill rapidly from the capillary side. Stasis is overcome and acceleration of the blood stream must result. Clinical evidence of the results of diminished blood supply is afforded by the pale muscle of the paralytic limb, the decalcified bone in disuse, and the cold extremity following inactivity. Biomicroscopic evidence is afforded by the work of Brown and Roth, who found that during exercise the number of open capillaries per square millimeter of skin is greatly increased, while other investigators showed that in the normal active individual the capillaries in the nail bed are closely packed in hairpinlike loops, while those of the inactive arthritic hand are much less numerous and narrower, indicating a diminished blood supply.

In the healing of fractures early motion is desirable, because motion causes pressure on the immature callus and pressure exerts a trophic influence, favorable to ossification. This explains the value of limited weight-bearing in delayed union; but internal stress on the bone, as Carey has shown, may be brought about by muscular contraction, a dynamic force, as well as by the static force due to transmission of body weight. In fact, the dynamic stress due to muscular contraction may far exceed the static stress. As long ago as 1894, Roux called attention to the facts that functional stimuli have trophic effects, that under the influence of tension young connective tissue is transformed into strong fibrous tissue, and that pressure, either alternating with tension or without tension, produces bone. In his admirable book on bone formation, Jansen goes a step farther and brings evidence to prove that, contrary to Wolff's law, bone is laid down not in response to trophic stimuli of both tension and pressure but to pressure alone. He states that fibrous tissue which has been submitted to tension remains fibrous throughout the life of the individual. That fibrous tissue, interposed between fracture surfaces, can be transformed into bone or replaced by bone, if the shearing force is eliminated, has been proved by the writer in experimental work on the dog. In a number of dogs the neck of the femur was cut through with a chisel and a full-thickness flap of capsule, completely covering the fracture surfaces, was interposed. Reduction was maintained by internal fixation secured by three knitting-needle spikes. Tension or shearing force was thus replaced by pure stress or pressure, and, in the five cases in which healing was allowed to progress for four months or longer before the animals were sacrificed, bony union resulted. In fractures of the ribs, where apposition is secure and function is uninterrupted, due to respiratory movements, healing takes place in a minimum of time. The closer we can approach this ideal of accurate reduction and uninterrupted function, the happier will be our results in fractures. Sling-suspension exercises, balanced traction and other similar devices, under-water exercises, in short, any method which will allow motion of the neighboring joints at an early date without jeopardizing the position of the fragments, should be utilized in the treatment of fractures. Murray and others are of the opinion that not infrequently disability after injury may be prolonged by the patient's

reliance on the physiotherapist to bring about his recovery by the application of some of the newer so-called modalities, with the resultant comparative neglect of the much more important voluntary effort in the rehabilitation program. The surgeon will do well to devote some time to the provision and proper arrangement of simple apparatus and to the supervision of at least the initial efforts of the patient. "Muscle setting", or static exercises with the limb still in plaster or splint, is also valuable, not only in diminishing joint stiffness, but in providing the trophic stimulus conducive to bone formation as a result of the dynamic stress.

OCCUPATIONAL THERAPY

Occupational therapy deserves special mention. When properly employed, with active exercise its basic principle, it is without doubt one of the most valuable adjuncts to physical therapy. If the program for the individual patient is carefully thought out and work properly planned and graduated, the injured are restored earlier to mental and physical fitness. While hospitals generally should be equipped at least to initiate this form of treatment, the community workshop with highly trained personnel will solve the problem for the more difficult cases.

POSTURE

In the reconstruction program the question of posture is often given insufficient consideration. This holds true for the position of the part, which often results in preventable deformities and disabilities such as adduction contracture of the shoulder and drop-foot, as well as for the body as a whole. It is deplorable to see crippled arthritics hunched up in bed or in wheel chairs, exemplifying every vicious feature of defective posture. Swaim has demonstrated before this organization how much can be accomplished by way of correction and how important this correction is in the general physiology. If prophylaxis were properly stressed, many of the most severe deformities could be avoided. The deformities in the arthritics and in many other patients can be predicted with considerable accuracy and in a large part prevented by postural measures. Among such measures the prone-lying position deserves special mention, because of its effect in simultaneous correction of flexion contractures of both hips and knees.

IRRADIATION AND DIATHERMY

I have dwelt at some length on the simpler forms of physical therapy, because in the conduct of our own work all other forms combined have not contributed more than about 10 per cent. of the total effort in this direction. We still have a great deal to learn concerning the fundamental effect on physiological and biological processes of the various forms of radiation. As regards ultra-violet radiation, we know only that it will cure rickets and promote the development of sound bones and teeth. The misuse of this agent has led several large insurance companies in this state to discourage the use of ultra-violet radiation in industrial cases.

Time will not permit discussion of radiotherapy, involving the use of the roentgen-ray and of radium. Fortunately, this form of therapy is very largely in the hands of a comparatively few highly trained physicians, to whose judgment most of us will be very happy to defer on special occasions when radiosensitivity of bone tumors and like problems present themselves.

As to diathermy, I will quote Coulter: "Well-established evidence indicates that local application of heat is effective as an adjunct in the treatment of certain traumatic and inflammatory changes in bones, bursae, muscles, ligaments, and tendons. Both long and short-wave diathermy are effective methods of applying heat and can be used to advantage for many of these conditions. There is no available evidence that medical diathermy has any effect other than that due to heat produced."

CONCLUSIONS

In general, one may say that too much emphasis cannot be laid on diagnosis, that the burden of proof rests on him who advocates the widening of the scope of physical therapy, and that, in the absence of proof, conservatism and a careful guarding against unwarranted enthusiasm are indicated.

Scientific evidence and clinical proof must come from well-trained and tried impartial investigators who are in a position to give us results of treatment, checked up by suitable controls. We will not look for this evidence in the reports of enthusiasts and optimists and we have no patience with those who continue treatment over interminable periods, finding their patients a little better each day, only to have a careful checking up show the condition unchanged.

The stocking up of the office of the young physician with expensive equipment of limited and doubtful value may bring him to the "cakes and ale stage" in a shorter time, but the price paid is not measured in dollars and cents. We need more men who will devote themselves earnestly to the basic problems involved, and more well-staffed and well-equipped institutions where diagnosis is taken seriously and where results are carefully observed, to help in the process of more clearly defining the legitimate field of the various agents and to restore physical therapy to the dignity it deserves.

REFERENCES

Brown, G. E., and Roth, Grace (The Mayo Clinic): Personal communication.

Carey, E. J.: Experimental Physiologic and Pathologic Muscular Back-Pressure and Its Relationship to the Formation, Regeneration, and Deformation of Bone. Anat. Record, XLVIII, Supplement, pp. 12, 69, 1931.

Clark, E. R., and Swenson, E. A. (Univ. of Pennsylvania): Personal communication.

Coulter, J. S.: Handbook of Physical Therapy, p. 342. Chicago, Am. Med. Assn., 1936.

Goldschmidt, Samuel, and Light, A. B.: A Comparison of the Gaseous Content of Blood from Veins of the Forearm and the Dorsal Surface of the Hand as Indica-

tive of Blood Flow and Metabolic Differences in the Parts. Am. J. Physiol., LXXIII, 127, 1925.

The Effect of Local Temperature upon the Peripheral Circulation and Metabolism of Tissues as Revealed by the Gaseous Content of Venous Blood. Am. J. Physiol., LXXIII, 146, 1925.

JANSEN, MURK: On Boneformation, p. 32. Manchester, England, The University Press, 1920.

LUCAS-CHAMPIONNIÈRE, JUST: The Treatment of Fractures by Mobilization and Massage. British Med. J., II, 981, 1908.

MENNELL, J. B.: Massage. Its Principles and Practice. Ed. 2. Philadelphia, P. Blakiston's Son & Co., 1920.

MOCK, H. E., PEMBERTON, RALPH, AND COULTER, J. S.: Principles and Practice of Physical Therapy, I, Chap. IV, p. 16. Hagerstown, Maryland, W. F. Prior Co., 1934.

MURRAY, C. R.: The Exact Rôle of Physical Therapy in the Treatment of Fractures. Surg. Gynec. Obstet., LVI, 479, 1933.

ROUX, WILHELM: Gesammelte Abhandlungen über Entwickelungsmechanik der Organismen, I, 357. Leipzig, Wilhelm Engelmann, 1895.

FRACTURES OF THE OS CALCIS

BY RICHARD O. SCHOFIELD, M.D., SACRAMENTO, CALIFORNIA

Formerly Chief Surgeon, Six Companies Hospital, Boulder City, Nevada

Any discussion of fractures of the os calcis can be undertaken only by acknowledging that there exist two distinct schools of thought in regard to the best method of treatment of this disabling condition. It is only by weighing these fundamental differences that one can conclude that certain procedures and steps in the treatment will produce an end result which will give a maximum restoration of function. The work of Böhler represents the greatest single contribution ever made toward the care of these fractures, and, having been privileged to follow closely his work, it has seemed to the author that this closed method of treatment offers distinct advantages over the various open types of reduction and arthrodesis that are advocated by others. Accordingly, at Boulder Dam the principles of the Böhler regimen were instituted and carried out in all of our cases. All treatments were given in our own hospital at Boulder City. These compensable industrial injuries were followed from the time the accident occurred until there had been complete healing and the patient had returned to work. When further improvement could not be obtained and when the condition of the cases was stationary, they were submitted for disposition to the Industrial Commissions of the States of Nevada and Arizona, who then estimated the percentage of disability. This rating,

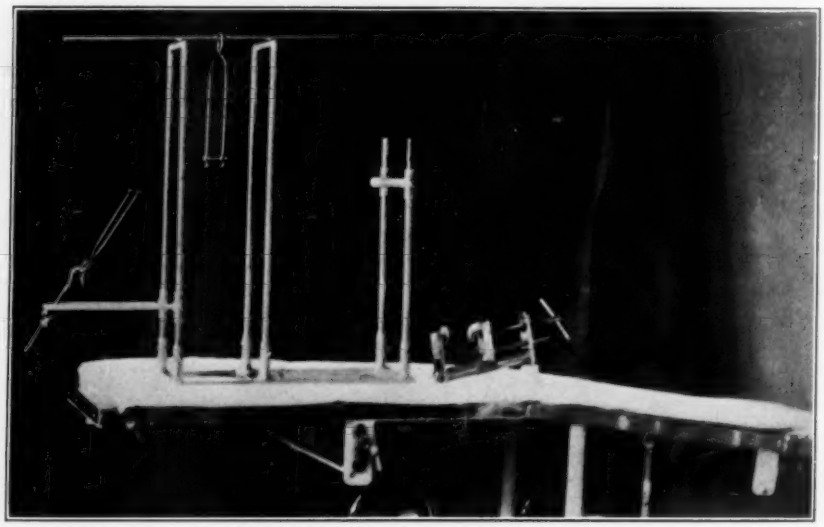


FIG. 1

Compression clamp and Böhler frame.

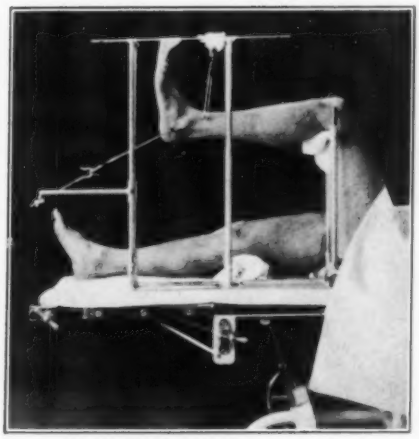


FIG. 2
Patient in Böhler frame.

FIG. 3
Illustrating use of compression clamp.

therefore, was made only when it had been established that the maximum restoration had been accomplished.

INCIDENCE

The total number of fractures which occurred, and upon which we have complete records, is 2,025. The incidence of occurrence of lesions of the os calcis was 2.56 per cent. The series comprises fifty-two consecutive cases and includes every case that occurred on the project. Of these fifty-two cases, 65 per cent. were caused by a fall and 35 per cent. by a blow. The average age of our patients was thirty-one years, the oldest

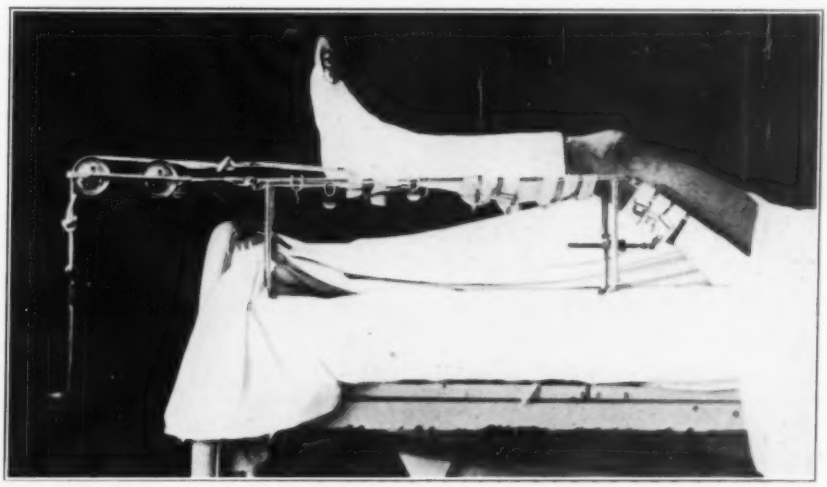


FIG. 4
Patient in Braun frame.

being fifty-two years and the youngest eighteen years. Four patients, or 8 per cent., had bilateral fracture of the os calcis. Twenty-five per cent. of the fractures of the os calcis were associated with other fractures of the ankle or foot; 12 per cent. were associated with vertebral fractures; and 1 per cent. were compounded.

PROCEDURES

Upon the occurrence of an accident, the injured man was moved only far enough away from the scene to be out of further danger (never more than a few feet). He was then promptly cared for by a competent first-aid attendant who made sure that rapid ambulance transportation would be accomplished without any disturbance to the injured parts. The patient usually arrived at the hospital in thirty minutes and not longer than sixty minutes after the accident occurred. While the radiographer was obtaining roentgenograms, an assistant doctor was present to care for the injured extremity and to attend to any other considerations that might be indicated for the patient's welfare. Views of the injured foot were made in the anteroposterior and lateral positions, and an axial view was made of the os calcis; corresponding views of the uninjured foot were obtained for comparison, and further special detailed views were always taken when they were needed to clear up some apparent diagnostic uncertainty. Roentgenograms were made of the back when pain was complained of in that area, and, during the treatment of the last third of this series of cases, x-rays of the lower dorsal and the lumbar vertebrae were routinely taken, because of the often existent and too often overlooked concurrent injury of these parts.

FIG. 5

Showing walking stirrup incorporated in cast.

CLASSIFICATION

The types of fractures encountered, together with the number and percentage of each, and the treatment afforded in each instance, are discussed in the following analyses:

TABLE I

TYPE-I FRACTURE

Time in Hospital	Complications	Cast Worn	No Weight-Bearing	Time Off	Time Rated	Functional Loss
11 days	None	14 weeks	2 months	5 months	8 months	6 per cent.

Type I

This is the so-called avulsion fracture with medial displacement of the sustentaculum tali, which occurred in only one instance, or 2 per cent. of the cases. The treatment consisted of compression made directly over the displaced fragment and the application of a cast with the foot inverted and dorsiflexed.

Type II

This is fracture of the body with no displacement of fragments, which does not involve any articular surfaces, and which causes no disturbance in the salient angle*. This type occurred in one instance, or 2

FIG. 6-A

FIG. 6-B

FIG. 6-C

FIG. 6-D

Fig. 6-A: Case 1. Initial lateral view of right foot.
Fig. 6-B: Case 1. Initial axial view of right foot.
Fig. 6-C: Case 1. Lateral view of right foot, showing end result.
Fig. 6-D: Case 1. Axial view of right foot, showing end result.

* This salient angle (Fig.11-C) or tuberosity-joint angle is a designation coined by Böhler that is graphically represented by the projection of two intersecting lines,—one drawn through the superior aspect and the anterior-superior angle of the bone, the other drawn through the same superior aspect and the uppermost border of the tuberosity.

per cent. of our cases. Treatment consisted of the application of a cast with the foot in midposition and in dorsiflexion.

TABLE II

TYPE-II FRACTURE

Time in Hospital	Complications	Cast Worn	No Weight-Bearing	Time Off	Time Rated	Functional Loss
4 days	None	1 month	2 months	3 months	6 months	0

Type III

This type includes fractures of the medial process of the tuberosity. It occurred in seventeen instances and comprised 33 per cent. of the fractures found in this series. In each case the injury was caused by a vertical fall and the appearance of the lesion is shown in Figures 6-A, 6-B, 7-A, and 7-B.

After the site of fracture had been injected with 2 per cent. novocain, the soft-tissue swelling was molded out and the fragment or fragments were returned to their anatomical position by using the Böhler compression clamp. Check-up roentgenograms were taken and an unpadded

TABLE III

TYPE-III FRACTURE

Time in Hospital	Complications	Cast Worn	No Weight-Bearing	Time Off	Time Rated	Functional Loss
(*Days*)		(*Weeks*)	(*Months*)	(*Months*)	(*Months*)	(*Per Cent.*)
15	Foot and spine	8	3	4	7	3
3	None	8	3	5	6	0
3	None	6	4	6	12	0
0	None	8	2	3	10	0
36	None	10	5	9	10	10
14	Foot	8	3	6	7	0
14	None	6	3	6	10	12
0	None	6	2	3	5	0
5	Spine	8	3	5	6	2
15	Foot and spine	6	3	4	7	2
4	None	4	1	2	3	0
2	Spine	8	3	6	9	3
0	None	6	3	5	8	0
42	None	8	3	5	14	5
14	None	8	2	4	6	0
8	Foot	8	3	4	8	3
42	None	6	3	4	14	0
Average 13 days		7 weeks	3 months	5 months	8.3 months	2.3 per cent.

cast was applied from a point just below the knee to one-half an inch beyond the large toe, with the foot in midposition and in dorsiflexion. Occasionally, a walking stirrup was applied immediately, but more often this was deferred several days, during which time the patient remained hospitalized with the injured foot in the elevated position.

This group is summarized in Table III, and the end results are illustrated by Figures 6-C, 6-D, 7-C, and 7-D.

Type IV

This type includes the fractures of the trochlear process and those of the anterior portion of the body of the bone which involve the cuboid articulation and possibly the minor anterior facet of the astragalus. The salient angle was very seldom disturbed and there was no injury to the tuberosity. The injury received was always a direct blow; in many instances, the anterior half of the foot was in a fixed position and the blow came from the side to the heel portion which was not in a fixed position. The group comprised ten cases, or 19 per cent. of the series, and the pathology of this type is shown in Figures 8-A, 8-C, 8-E, 9, and 10.

In three of these cases reduction was obtained by the screw-traction apparatus. In the other seven, the fractures were reduced by manual traction on the heel, which was sufficient to separate the articular facets and to produce a reposition of the impinged fragments. An unpadded cast was applied from the knee to the toes and the walking stirrup was placed on the cast, usually on the second day.

The group summary is contained in Table IV, and the end results are shown in Figures 8-B, 8-D, and 8-F.

TABLE IV

TYPE-IV FRACTURE

Time in Hospital	Complications	Cast Worn	No Weight-Bearing	Time Off	Time Rated	Functional Loss
(*Days*)		(*Weeks*)	(*Months*)	(*Months*)	(*Months*)	(*Per Cent.*)
5	Foot	4	2	4	6	0
12	Ankle	8	3	5	9	0
14	Foot and spine	4	2	4	18	5
12	None	2	1	2	8	0
2	None	2	1	1	2	0
1	None	3	2	3	4	3
1	Ankle	4	2	4	10	12
5	None	8	2	3	9	0
1	None	0	0	1	6	0
2	None	4	2	2	3	0
Average 5 days		4 weeks	1.7 months	3 months	7.5 months	2 per cent.

Type V

This type comprises comminuted fractures of the body with displacement and oftentimes compression and impaction of the fragments. In our series, these fractures always involved the subastragaloid joint and usually the cuboid articulation, and the whole architecture of the bone was altered (Figs. 11-A and 11-B). There is a disturbance made in the salient angle. Normally this angle is about 27 degrees, but with this type of fracture it is decreased, or may be obliterated, or entirely reversed (Fig. 11-A). This group included twenty-three cases, or 44 per cent. of the series. The cause of the injury was a vertical fall in eighteen instances and a direct blow in five instances. This type of fracture affords the classic illustration of the principles of the Böhler technique, which makes use of the skeletal transfixion pins, the compression clamp, and the screw-traction frame (Fig. 1). The summary of these cases is shown in Table V.

TABLE V

TYPE-V FRACTURE

Time in Hospital	Complications	Cast Worn	No Weight-Bearing	Time Off	Time Rated	Functional Loss
(*Days*)		(*Months*)	(*Months*)	(*Months*)	(*Months*)	(*Per Cent.*)
60	None	3	5	8	10	18
35	None	3	5	8	14	20
35	None	3	4	5	8	5
40	None	5	5	7	9	8
60	Spine	4	5	8	11	7
10	Foot	3	6	13	16	15
64	None	3	5	7	12	10
30	None	2	3	4	5	0
70	Foot	3	4	8	10	10
10	None	2	4	10	18	20
2	None	2	3	5	6	0
15	Ankle	3	4	6	12	5
3	None	3	2	3	6	0
30	None	4	4	6	8	10
30	None	1	4	7	12	10
30	None	2	3	6	7	3
30	None	3	5	6	8	5
30	Ankle	2	4	8	14	10
35	None	3	4	6	8	5
30	Foot	2	4	5	9	18
40	None	4	5	8	9	10
Average 33 days		11 weeks	4 months	7 months	10 months	9 per cent.
17 months	Osteomyelitis	1 month	12 months	2 years	2 years	25
17 months	Osteomyelitis	3 months	16 months	2 years	2 years	55
Average 74 days		11 weeks	5 months	8.3 months	11 months	12 per cent.

These fractures were reduced as soon as possible after the injury occurred, and in many instances only a moderate swelling had opportunity to take place. The usual time which elapsed between injury and reduction was less than sixteen hours; the shortest time was three hours and the longest was seven days.

Anaesthesia was obtained by dissolving 100 to 150 milligrams of novocain directly in the spinal fluid, after which the lower leg was cleansed with soap and water, alcohol, and ether.

An attempt was then made to break up any impaction, and the swelling around the ankle and heel was ironed out.

There must be a reposition of the fragments in such a manner as to insure a return of the normal salient angle, which is determined in a lateral roentgenogram, and to correct the widening out that occurs in the plantar

FIG. 7-A

FIG. 7-B

FIG. 7-C

FIG. 7-D

Fig. 7-A: Case 2. Initial lateral view of left foot.
Fig. 7-B: Case 2. Initial axial view of left foot.
Fig. 7-C: Case 2. Lateral view of left foot ten months after injury.
Fig. 7-D: Case 2. Axial view of left foot ten months after injury.

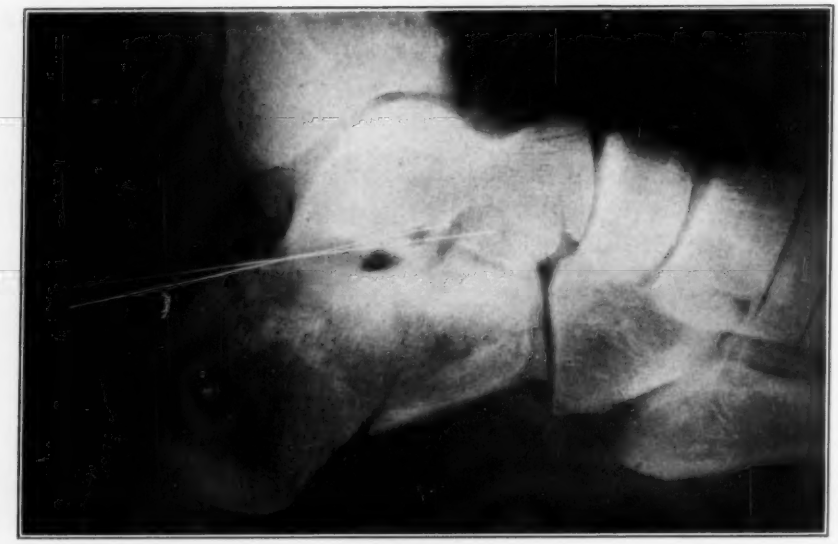


FIG. 8-A

Case 3. Initial lateral view of left foot.

surface of the heel, as shown in the axial view. Fulfilment of these two requisites is essential to minimize or to prevent functional loss.

The skin at the site of introduction of the solid Böhler pin (three-sixteenths of an inch) into the os calcis was painted with 3 per cent. iodine solution (one-half tincture strength). With the foot in dorsiflexion, the pin

FIG. 8-B

Case 3. Lateral view of left foot seven months after injury.

FIG. 8-C

Case 3. Initial axial view of left foot.

FIG. 8-D

Case 3. Axial view of left foot seven months after injury.

FIG. 8-E

Case 3. Initial anteroposterior view of left foot.

FIG. 8-F

Case 3. Anteroposterior view of left foot seven months after injury.

FIG. 9
Case 4. Lateral view of left foot.

FIG. 10
Case 5. Lateral view of right foot.

was driven through the heel bone and the U tractor was applied. On more than one occasion, as the process of reduction proceeded, it was necessary to remove the pin and to replace it in a slightly different position in order to get the proper pull to bring about the best realignment of the several fragments when traction was applied. In two cases, the point of pin insertion was between the bone and the tendo achillis, because this point of application of traction produced the best anatomical reposition of the fragments. The tibial pin was introduced in a like manner and the U tractor was applied. With the knee flexed, the leg was placed in the extension frame (Fig. 2) and traction was provided in the exact manner so often described by Böhler. This was followed by the use of the compression clamp (Fig. 3). Check-up roentgenograms were taken, and, when the salient angle was restored and reposition of the fragments was obtained (Figs. 11-C and 11-D), the cast was applied. The cast extends from a point two inches below the proximal fibular head to one-half an inch beyond the end of the large toe, the foot being in midposition and dorsiflexed never more than to a right angle. Another check-up roentgenogram was taken, after which the tibial pin was removed, the patient was returned to his room, and the leg was placed on the Braun frame with a seven-pound weight attached to the U tractor on the os-calcis pin (Fig. 4).

When such a fracture is reduced and the foot is immobilized in an unpadded plaster cast, it is highly important that the toes be checked every hour or so during the first twenty-four hours to detect any nerve or ischaemic disturbances. Seldom was it necessary to bivalve the whole cast, but very often the cast was cut over the dorsum of the foot or split

FIG. 11-A

Case 6. Initial lateral view of left foot.

FIG. 11-B

Case 6. Initial axial view of left foot.

FIG. 11-C

Case 6. During reduction in Böhler frame.

FIG. 11-D

Case 6. After compression clamp has been applied.

FIG. 11-E

Case 6. Lateral view six months after injury.

FIG. 11-F

Case 6. Axial view of left foot six months after injury.

over its uppermost portion toward the knee. Complete removal was necessary in two instances, in both of which a second cast was applied in twenty-four hours. These are daring procedures when a non-padded cast is used, and they certainly court disaster if experienced nurses and

FIG. 12-A

Case 7. Lateral view of right foot nineteen months after injury.

FIG. 12-B

Case 7. Lateral view of left foot nineteen months after injury.

assistant doctors are not constantly observing the condition of the extremity. The cast was routinely removed and the entire extremity was inspected every twenty-one days. The leg was always replaced in a supportive position in the Böhler traction frame when the first cast was removed and the second was applied. The precautionary use of the traction frame is always necessary during this first change of casts, but it does not have to be continued on subsequent occasions.

Extension is maintained on the os-calcis pin for six weeks, which represents the life of the first two casts; after this, the pin is removed and the third cast is applied. The walking stirrup (Fig. 5) was usually applied to this cast in another week or ten days. The final result is illustrated in Figures 11-E and 11-F.

It might be pointed out that, if we excluded the one patient who had bilateral fracture of the os calcis, and who developed an osteomyelitis in each heel, there would be shown an average of only 9-per cent. disability for the group. This is the only case in which we have encountered any difficulties from the use of the skeletal pin traction, and we must presume that the osteomyelitis developed through the use of the pin, although the technique in this instance was no different from that employed on all of the other occasions. Figures 12-A and 12-B show the end results obtained in each heel.

When weight-bearing and walking are first commenced, the patient is specifically instructed and shown how to walk with an erect head and body, with a short, well-measured stride which should be absolutely equal with each leg. This precaution prevents the acquisition of an unnatural gait and limp which always emphasize the disability both to the patient and to his friends.

The presence of pain demands an examination of the foot. A routine examination of the injured foot is made every five days for many weeks and this allows for the institution of any needful measures for temporary assistance, such as adhesive strapping for a weakened ankle or the application of metatarsal pads for a flattening arch.

CONCLUSIONS

The closed method of reduction of fractures of the os calcis has given us an exceedingly low functional foot loss. Kessler[1] estimates that the most severe form of this fracture, which has been discussed as Type V, results in a minimum disability of 20-per cent. loss of function of the foot. There were only two instances in which even this minimum was exceeded and the average loss of function was only 12 per cent.

After healing has occurred, it is not uncommon to find that the architecture of the injured foot has been restored to an apparently normal condition, yet the patient may complain of varying degrees of pain, particularly below the malleoli. Pain on the plantar weight-bearing surface of the tuberosity is seldom as severe or as persistent as that which is found laterally, especially under the external malleolus.

The loss of motion in eversion and inversion constitutes the greatest type of residual disability.

The more severe associated vertebral injuries have occurred in Type-III fractures, in which the medial condyle of the tuberosity is split off, and not in the severe comminuted cases seen in Type 5.

Skeletal traction and extension separate the subastragaloid and the cuboid articular surfaces, and this procedure also restores the architecture which will permit the resumption of the normal mechanics in the foot for weight-bearing and locomotion.

In the series of cases upon which this paper is based, the youth of the patients, the promptness of first-aid attention, and the complete facilities provided for adequate care and early reduction of these fractures undoubtedly accounted in a large measure for the low residual disabilities obtained.

Successful fracture treatment is predicated upon the interpretation of dependable and detailed roentgenograms; in this department the author has been aided by the cooperation and untiring work done by our radiographer, Mr. Ewald J. Larson, who is also responsible for the illustrations that have been used. The writer also wishes to express his appreciation to the following members of his staff—Dr. J. W. Williams, Dr. J. M. Kehoe, Dr. William T. Burton, Dr. A. G. Clark, Dr. F. M. Sutton, Dr. R. F. Jackle, and Dr. W. C. Klein—who have so ably assisted in making these results possible.

REFERENCE

1. Kessler, H. H.: Accidental Injuries: The Medico-Legal Aspects of Workmen's Compensation and Public Liability. Philadelphia, Lea & Febiger, 1931.

SOME THOUGHTS ON THE PROBABLE CAUSES OF NON-UNION OF FRACTURES

BY PROF. HENRY TURNER, M.D., LENINGRAD, U.S.S.R.

Professor, Military Medical Academy;
Honorary Director of Institute for Crippled Children

The capacity of fractured bones to solidify in a few weeks and to regain their functional activity may be regarded as one of the manifestations of nature's remarkable healing power. The almost daily observation of this favorable result in fractures has somewhat diminished the interest in the intrinsic biological process which effects firm soldering of the bone fragments.

There can be no doubt that the initial quick uprising of forces which form the basis of fracture healing is stimulated and controlled by nervous factors. Acute pain, generally experienced at the site of the fracture, is the signal which calls attention to the injury and dictates the treatment, the essence of which is rest to the injured region. It may be said that the rational treatment of fractures is based on this fundamental demand for rest on the part of nature.

In considering briefly the process of consolidation of a fracture, it is permissible to compare it to what in modern technical language is known as autogenous welding,—the melting together of contiguous parts of metal and thus restoring the integrity of the disjoined parts. The process of bone union takes place in a similar manner and consists of a softening of the fragment ends and a certain degree of autolysis called "*Abbau*" by the Germans (König). This effect is produced by decalcification, the degree and limits of which vary in each case in proportion to nature's task and to the stimulant which underlies this mysterious process. The quickly formed plastic mass is then poured out between the fragments and unites them. Impregnation of this provisional callus by lime salts hardens the mass which later undergoes a process of shaping and transformation into bone tissue. Finally, no line of fracture can be seen and there remains as evidence of the injury only a slight cortical thickening which may be compared to a plumber's joint.

In contrast to the favorable course described, not infrequently the tendency to consolidation is slight and delayed precarious union, fibrous union, or pseudarthrosis may result. The abundant literature dedicated to the investigation of the factor which underlies this stubborn resistance to union is unanimous in asserting that all attempts to solve this problem have been fruitless. Briefly, the theories which have been advanced to account for non-union are: interposition of muscle or other soft tissue, inadequate reduction of the fragments and insufficient immobilization, severe traumatization of the soft parts, damage to the blood supply, and the formation of amino acids from hematomata and dead tissue. The

FIG. 1

Roentgenograms showing typical decalcification of the foot in a case of fracture of the right leg with non-union of three months' duration. The normal left foot is shown for comparison.

theory last mentioned—that a chemical agent is produced which is capable of decalcifying bone tissue—does not account for the constant component of a fracture. Many laboratory investigations have been carried out in the vain attempt to base the cause of non-union of fractures on some chemical abnormality of the blood, especially calcium and phosphorus deficiency. Recognizing the failure of finding a single factor in the production of pseudarthrosis, some authors are inclined to admit multiplicity of causes, including constitutional disturbances, physiological inertia, and other not well-defined agencies. Vitamin deficiency in diet is also included. Of the various explanations which have been suggested for the occurrence of pseudarthrosis, the influence of nervous factors is hardly mentioned. As an important element, this has not received adequate attention.

In the beginning of this paper, the author mentioned the significant fact that the sensitive nerve fibers call attention to a fracture immediately

after it has occurred. It seems reasonable to suggest that the specific acute pain which accompanies the fracture originates in the lacerated or bruised nerve fibers contained in the bone or its periosteum. We may repeat with Macewen that the solidity and hardness presented by diaphyseal bone are apt to convey the impression of immutability, whereas there are few animal tissues more prone to interstitial changes. The rôle of bone innervation in this process cannot be doubted.

The dawn of roentgenoscopy brought to light a very common pathological change in bone structure which was designated by its first observers (Sudeck, Kienböck) as acute bone atrophy. (See Figure 1.) The veil of obscurity enveloping its origin has grown thinner since the condition has been definitely linked with trauma which involves the peripheral-nerve branches. Actually representing acute bone decalcification (halisteresis), it came to be a habitual component of a clinical syndrome consisting of neuromuscular, vasomotor, secretory, trophic, and other disturbances. Well-defined morbid entities, described by the Germans as "*hartes Oedem des Handrückens*" and "*Fussgeschwulst*", presented themselves as types of complicated reflex reaction to disguised nervous irritation of traumatic origin.

A series of articles which have been published by the author and his associates since 1924 serves to prove the frequency of wide-spread decalcification, due to peripheral neuritis, in fractures and other ordinary injuries of the extremities. In some cases of Colles' fracture which followed an abnormal course, decalcification, in conjunction with the other symptoms of reflex origin, was particularly evident. With increased attention and more frequent recourse to roentgenoscopy, the author has been able to demonstrate the same rarefaction of bone in cases of injuries of the carpal or metacarpal bones as in cases of corresponding trauma to the foot. (See Figures 2, 3, and 4.)

An etiological connection between traumatic neuritis and bone atrophy has not escaped the attention of neurologists. We find the following lines on this subject in Dejerine's excellent handbook: "Finally there has been pointed out the existence of bone atrophy resulting from nerve injuries (Moty, 1892); this author has reported two cases of fracture of the leg with consequent neuritis and atrophy of the skeleton of the foot. The atrophy might develop rapidly at the end of two months; in the foot it was manifested in the tarsus and metatarsus, more rarely in the toes. These observations are interesting, but they have not been confirmed by anatomical examination of the so called atrophic bones."

The term "*ostéoporose traumatique*", recently introduced by Leriche, is used to denote the same phenomenon.

Heydemann, in 1933, described a well-defined process of acute traumatic bone atrophy, associated with fractures, as a result of circulatory disturbances. According to this author, some degree of atrophy occurs after most fractures and is demonstrable in roentgenograms if sufficient attention is paid to the peripheral portions of the bone close to the joint.

The author's repeated success in interrupting the afferent stream of irritation by sectioning or blocking a located sensitive nerve branch, and thereby stopping the obvious progress of decalcification, fully justifies his suggestions as to the etiology of its origin. From a wide clinical experience of many years, it may be asserted that the manifestations of peripheral-nerve irritation following fractures or other minor injuries of the extremities do not receive the consideration they deserve, and in a large number of cases they are entirely overlooked.

The evidence that bone tissue is susceptible to irritation originating in single nerve branches adds further support to the theory that the primary factors in the healing of fractures are trophic in nature and are the result of localized traumatic neuritis. It, therefore, seems reasonable to suppose that, if the injured area is given complete rest, the nerve irritation will promptly subside, decalcification will cease, and recalcification of newly formed tissue will lead to firm soldering of the fragments. From this point of view, it is evident that inadequate treatment plays a significant rôle in hindering bone union. In the treatment the factors to be avoided are: incomplete or technically imperfect immobilization, tight bandages, early massage or functional exercises, frequent changes of bandages for the sake of roentgenographic examination, and other manoeuvers which prevent absolute rest.

FIG. 2

M. S., aged twenty, sustained a fracture of the right forearm on April 4, 1935. Roentgenograms taken in June show non-union and marked mottled decalcification of the carpal region.

It is interesting to note that Kienböck, one of the first writers on the subject of acute bone atrophy, pointed out the frequency of this phenomenon in cases of pseudarthrosis of the forearm, but was not able to give a satisfactory explanation of its occurrence. It is an accepted fact that roentgenographic examination is generally confined to the site of fracture; if the familiar picture of non-union is observed, the examiner usually does not extend the examination. If the study of the injured bones is carried further, there are likely to be revealed wide-spread structural changes. The process of decalcification appears to be distinctly marked in the peripheral portions of the limb. The transparency of

FIG. 3

M. S. Roentgenogram showing the distal part of the extremity (right) as compared with the sound side (left). Note the conspicuous decalcification of the skeleton of the hand.

FIG. 4

M. S. Roentgenogram of right extremity, five months later than Fig. 3, showing perfect consolidation. The decalcification is less marked and the outlines of the bones of the hand are more distinct as a result of the blocking of the radial nerve by alcohol near the capitulum radii and of immobilization of the extremity in a plaster splint.

the skeleton of the hand or foot astounds the observer. A comparison with the sound extremity will help even an inexperienced eye to recognize lighter forms of rarefaction. A minute examination generally shows that the thinned bone shadow is not of uniform density and presents a mottled appearance,—the "*fleckige Atrophie*" of Sudeck. This finding permits some plausible suggestions as to the origin of bone decalcification. Recent investigations of a number of workers in biological chemistry (Sherrington, Levi, Dale, Dixon, Cannon, and others) have shown that the transmission of a nerve impulse to the muscle is performed in a physicochemical way. An excitatory substance of an acid type is released at the junction of the nerve and muscle and thereby activates the muscle. Acetylcholine is suggested as being the most probable chemical agent. It, therefore, seems safe to apply the same theory to the explanation of acute bone atrophy. In the face of rapid disappearance of lime salts from the substance of bone, it is only natural to suspect an acid solvent which arises from the nerve endings that convey distal irritation. This hypothesis may account

for the mottled character of the rarefaction seen in the roentgenogram.*

In some cases it is possible for an experienced eye to discern a cloudy area which obscures the faint outlines of the injured region. The impression is obtained that this cloudy appearance is caused by the permeation of lime salts into the soft parts in the vicinity of the fracture where they remain and assist in the process of repair.

It may be expected that biological chemistry, in the course of its rapid development, will be able to explain the significance of these clinical facts in relation to bone pathology. Physiological research will serve to determine the separate links of the chain by which nervous irritation of peripheral origin is transmitted to the substance of bone.

The practical application of knowledge already obtained is not to be underestimated. The recognition that acute trophic rarefaction frequently complicates fractures is a further step toward our understanding of the cause of occasional cases of non-union. It is easy to understand nature's difficulty in healing a fracture if the necessary cementing material is being carried away from the site of injury.

FIG. 5

Case 1. G. N. Severe neurotrophic decalcification of the skeleton of the foot, due to irritation of the saphenous branches caused by a nail driven through the metaphysis of the fractured femur.

CASE 1. G. N., female, aged twenty-four, an engineer, sustained a fracture of the right femur on August 31, 1934. On admission to the hospital she was treated by extension with the aid of a nail driven through the tibial tuberosity. This treatment was continued for six weeks, during which time the patient suffered constant pain. Extension was discontinued because of suppuration about the nail, and immobilization was secured by plaster bandages.

The patient entered the Orthopaedic Clinic in the middle of November 1934. She was in a highly nervous condition and complained of pain which extended along the inner side of the injured limb from the groin down to the ankle. Fistulae on either side of the tibial tuberosity discharged freely. Digital pressure below the middle fistula occasioned great pain, which descended upward, downward, and along the limb and caused profuse sweating. Wasting of the muscles of the thigh was marked.

*A case of the development of local acidity during callus formation has been described by Häbler.

Roentgenographic examination revealed an ununited transverse fracture of the femur with lateral displacement of the fragments. On November 22 a well-fitting plaster bandage, enclosing the pelvis and the foot, was applied. The effect of complete immobilization was immediate. The pain subsided, the irritability of the patient became less, and she slept quietly. A slight percussion of the site of the fracture through a window was prescribed to stimulate the reparatory process.

On January 28, 1935, the heavy bandage was removed and slight extension with the aid of a plaster-of-Paris cuff, enclosing the semiflexed knee, was substituted. Consolidation of the fragments was already apparent. Suppuration ceased after slight curettage of the fistulae which contained small sequestra.

On February 26, 1935, a roentgenogram of the right foot showed a remarkable degree of decalcification, particularly affecting the tarsal and metatarsal bones (Fig. 5).

The patient left the Clinic on March 26, 1935, using a walking stick. There was perfect consolidation of the fragments. Physiotherapy and mechanotherapy were prescribed to increase the range of motion in the stiffened knee and to relieve the neuritis.

Summing up the foregoing clinical history, the following interpretation can be offered. The unfavorable effect of the early inadequate immobilization was enhanced by acute neuritis occasioned by the trauma and suppuration from the skeletal traction. The ramifications of the saphenous and obturator nerves on the inner side of the knee were the source of severe irritation and of the trophic factor which prevented consolidation. Complete rest by immobilization turned the healing process into its normal course. In relation to the final result which occurred after complete immobilization, the question may be raised whether or not the case should be considered as so called delayed union or non-union.

CASE 2. M. F., male, aged twenty-three, a horseman, fell from his horse in November 1933 and sustained a complicated fracture of the left leg. He was admitted to the hospital within a few hours. After the limb had been immobilized for two days in a wire gutter, a nail was driven through the heel for traction. During the following sixteen days the patient suffered incessant severe pain produced by the nail. On account of suppurative osteomyelitis, the nail was removed and a plaster bandage, with windows for dressing the wound, was applied. This remained *in situ* for twenty-eight days, during which small fragments of bone were discharged from the wound. Subsequent treatment consisted of extension by adhesive plaster, followed by a plaster-of-Paris bandage which was frequently changed for inspection of the wound.

After three months, non-union was evident. Weight-bearing was then instituted according to the method of Delbet and continued for from two to three months. Circulatory disturbances produced by pressure of the Delbet plaster splints were evident as indicated by the blueness and swelling of the foot. Pain in the leg continued to be severe.

In the summer of 1934 hot-mud treatment was resorted to in the Crimea, and a molded leather splint was applied to the limb. On September 7, 1934, Leriche's sympathectomy was performed, but it had no effect on the pseudarthrosis. An osteosynthesis was then performed on November 27. Difficulties experienced in inserting the intermedullary graft led to fixation by a wire loop. The final result was negative.

The patient was admitted to the Orthopaedic Clinic on September 4, 1935, with evident symptoms of pseudarthrosis of the tibia and anterior angular curvature. Roentgenographic examination revealed distinct non-union and marked decalcification of the bones of the foot. The line of fracture was transverse and there was marked sclerosis of the ends of the fragments which were held together by a wire loop. The remains of the heterogenous bone graft were seen in the medullary cavity of the lower fragment. The fibula, which had been fractured higher than the tibia, was firmly con-

solidated. Muscular atrophy was marked. The peroneal nerve was extremely sensitive to pressure in its course behind and below the head of the fibula. The patient walked with the aid of a crutch. His chief complaint was pain in the leg.

Treatment consisted of the application of a well-fitting plaster-of-Paris bandage reaching to the knee. A few drops of 60-per-cent. alcohol were injected behind the head of the fibula to quiet the neuritic pain. Pressure on the sole of the foot when walking was allowed. Consolidation of the fragments was slow, but there was positive progress.

On November 11, because of the possibility of irritation the wire loop was extracted through a small incision under local anaesthesia. In order to stimulate the process of consolidation, the periosteum was slightly stripped off and a few holes were drilled in the fragments according to the method of Beck. This procedure quickened the callus formation. The patient left the Clinic without a cane on January 5, 1936. The pain had disappeared.

This second case is of exceptional interest. Restoration of function was obtained in a condition of common fracture of the tibia after more than two years of various forms of treatment. The principal factor in the healing—rest—remained in the background throughout the whole course of the primary treatment. A special point also deserves mention. It is well recognized that in cases of fracture of both bones of the leg the fibula usually unites more quickly and firmly than the tibia which often shows but a feeble tendency to consolidation. Various explanations have been suggested for this fact which has attracted little attention. According to Henderson and others, the early union of the fibula introduces a mechanical impediment,—the united bone acts as a pivot around which the fragments of the tibia swing. The author's repeated success in obtaining final union of the tibial fragments leads to the assumption of other theories. In spite of our somewhat limited knowledge of the innervation of bone, it may be assumed that ramifications of different nerves supply two separate bones. It is also admitted that the tibia receives more innervation and is, therefore, more sensitive to irritation.

Case 3. S. F., male, aged twenty-seven, an engineer, while riding a motorcycle on May 1, 1935, had a collision and received a complicated fracture of the middle of the lower third of the right leg. There was a contused wound on the medial side of the leg, corresponding in location to the site of the fracture. Treatment consisted of immobilization of the leg, including the knee, in plaster for three months. During this time the bandages were frequently changed. The external wound was slow in healing.

The patient was admitted to the Orthopaedic Clinic in August 1935. At that time there existed marked wasting of the muscles of the right lower leg, amounting to about three centimeters on the calf. A large reddened surface, partly cicatrized, was exposed after removal of the darkened superficial area caused by the prolonged application of silver nitrate to the wound.

Roentgenographic examination (Fig. 6) showed a transverse fracture of both bones at the same level, and non-union. The ends of the fragments were sclerosed and there was no trace of callus. There was decalcification of the distal fragments and especially of the bones of the foot. The "spotted atrophy" of the foot was particularly marked. The patient complained of severe pain in the injured area and sweating of the foot. There was marked sensitiveness to pressure over the branch of the cutaneous dorsalis intermedius on the anterior lateral surface of the ankle joint.

Treatment consisted of the application of a light plaster-of-Paris bandage, reaching from the foot to the knee. Previously, from fifteen to twenty drops of 70-per-cent. alcohol had been injected subdermally in the region of the painful nerve. Walking with

crutches was allowed. Percussion of the sole of the foot was performed daily as a stimulus.

After a period of two months, there was observed consolidation of the fragments with some callus formation. At the end of November, seven months after the accident, the patient was able to use the injured leg for support. By February 1936 the atrophy of the calf had diminished so that the part had resumed its normal appearance.

This case is regarded as a definite illustration of delayed union caused by peripheral-nerve irritation. Retarded healing of the wound, deficient callus formation, decalcification of the bones of the foot, and sensitiveness of the nerve branches all indicated trophoneurotic disturbances. Wasting of the muscles was particularly conspicuous.

CASE 4. P. M., a male, aged thirty-seven, was kicked by his horse on October 21, 1934 and sustained a complicated fracture of the right leg. Primary treatment in the hospital consisted of immobilization in plaster-of-Paris bandages. These bandages were changed frequently in order to control the position of the fragments. One month after the accident, an osteosynthesis was performed in which a heterogenous graft was used. Because of the severe pain following immobilization in plaster for two weeks, a Cramer splint was substituted for the plaster.

The patient was then transferred to another hospital. During January 1935 two

FIG. 6

Case 3. S. F. Mottled acute atrophy of the skeleton of the right foot accompanying non-union of the tibia of three months' duration.

injections of blood into the site of the fracture were given. Three intravenous injections of 10-per-cent. calcium-chloride solution were included in the succeeding treatment which was continued for some months without producing bone union. Drilling of the fragments, according to the method of Beck, was resorted to on April 28. During the following summer an attempt was made to reenforce the vitamin factors by the addition of tomatoes in large quantities to the diet. However, all of these therapeutic measures had no effect on the pseudarthrosis of the tibia.

On admission to the Orthopaedic Clinic, October 5, 1935, marked atrophy of the thigh and leg muscles was noted. There was considerable sweating of the distal portion of the extremity.

Roentgenographic examination revealed a fracture of both bones of the leg at the same level. The fragments of the fibula were firmly united by ossified callus. A crevice existed between the fragments of the tibia, traversing the indistinct remains of the intramedullary transplant. The decalcification of the tarsal and metatarsal bones and the phalanges was excessive and there was also atrophy of the bones of the leg.

Moderate mobility of the fragments in the sagittal plane could be detected by palpation. The patient complained of pain in the inner side of the limb from the knee to the ankle. Examination showed hyperaesthesia and painful sensibility of the subcutaneous nerve fibers on the same side. Weight-bearing was possible only with the aid of crutches.

The clinical findings indicated that the stubborn resistance of the tibia to union was definitely associated with neuritis which may have had its origin in the severe bruising of the soft parts at the time of the injury. Treatment was directed toward quieting the nerve irritation. Subcutaneous injections of small quantities of alcohol were made on the inner side of the leg near the sensitive nerve branches. The beneficial effect of the blocking was marked. The patient urged repetition of the injection in spite of the temporary pain produced. Other sensitive nerve branches were given the same treatment at different intervals. The patient was allowed to walk without crutches. A protective plaster splint was applied to the leg. Serial roentgenograms showed gradual fusion of the fragments of the tibia and osseous solidification of the crevice.

On January 5, 1936, after fourteen months of treatment, the patient returned to service with a useful leg.

Case 5. K. M. Y., a male, aged thirty, was run over by an automobile on September 27, 1934, and sustained a fracture of the left leg. He entered a hospital immediately, where treatment consisted of plaster-of-Paris bandages, frequently changed. Massage was begun one month after the accident. There was incessant severe pain. The patient entered the Orthopaedic Clinic on December 19, 1934, and a roentgenogram (Fig. 7-A), taken immediately, showed feeble attempts of the bone to consolidate during the three months of treatment. Five months after the accident, there was distinct decalcification of the skeleton of the foot on the injured side (Fig. 7-B). Treatment consisted of a well-fitting plaster-of-Paris bandage, including the knee, and light weight-bearing on the sole. A roentgenogram (Fig. 7-C), taken on March 3, 1935, after three months of firm fixation, showed abundant callus formation.

These clinical observations illustrate a phenomenon to which the author's attention has been increasingly attracted during these last years. No factor in the occurrence of these cases could account for the evident delay in bone consolidation which lasted from some months to more than two years, and the final results obtained in them contradict the theories usually advanced to explain the underlying cause, such as interposition or deficiency of bone tissue, etc. It would appear that interference and the frequent change of methods of treatment hinder nature's healing process in some cases. The essential obstacle to healing may be regarded

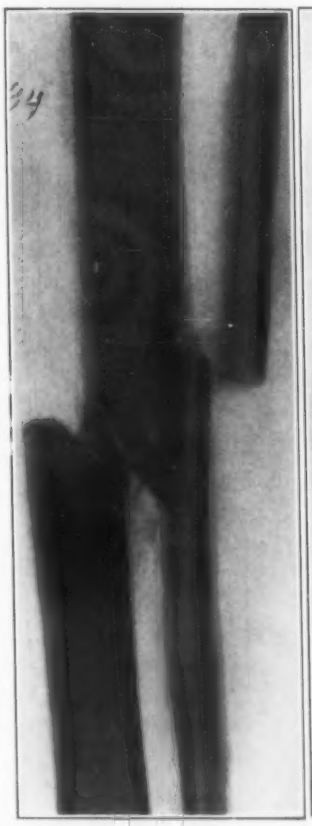


FIG. 7-A

FIG. 7-B

FIG. 7-C

Fig. 7-A: Case 5. K. M. Y. Roentgenogram, taken on December 19, 1934, three months after injury.
Fig. 7-B: Roentgenogram, taken five months after injury, showing distinct decalcification.
Fig. 7-C: Roentgenogram, taken on March 3, 1935, showing abundant callus formation.

in the light of a protraction and extension of a biological process which primarily stimulates bone union. The author ventures to suggest that some elements in the usual methods of treatment may create unnecessary sources of nerve irritation.

SUMMARY

Acute bone decalcification is an essential part of a biological process which, in cases of fracture, leads to bone union. This temporary rarefaction is reflex in nature and proceeds from traumatic irritation of the nerve branches which supply the bone and the periosteum. When the irritation subsides, this process is brought to a standstill and is replaced by deposition of lime salts in the newly formed soft callus and the decalcified ends of the fragments. A soldering of the fragments is thus obtained. In some cases, this irritation of the nerve branches continues for a long period and prevents nature from carrying out the normal healing process. Local deficiency of lime salts causes delay in bone union and may even prevent consolidation.

The etiology of this condition may be ascribed to unusual involvement of the sensitive nerve branches, due to trauma, or to methods of treatment which tend to maintain the irritation of the afferent nerve conductors. Fractures of the forearm and leg are especially prone to non-union because of their profuse and diversified innervation. In cases of fracture of the forearm, disregard of the rules of reduction and immobilization is an important factor in the production of pseudarthrosis. The sensitive nerve branches which may be chiefly accused of sustaining irritation and favoring non-union appear to originate in the upper part of the limb from the radial-nerve and ulnar-nerve cables. In the lower limb the corresponding sources are the obturator, saphenous, and peroneal nerves. A special branch of the peroneal nerve, located on the dorsum of the foot and known as the cutaneus dorsalis intermedius, has been found by the author to be especially prone to neuritis of a degree capable of producing marked decalcification. Another form of neuritis, associated with the treatment of fractures, arises from the modern free use of nail extension. Indiscriminate piercing of the bone in such profusely innervated regions as the inner side of the knee and the calcaneum frequently gives rise to stubborn neuritis with consequent wide-spread decalcification.

In the clinical examination of slowly healing fractures more attention should be paid to the possible involvement of the peripheral-nerve branches. Roentgenographic examination should not be limited to the immediate site of injury. Decalcification which extends toward the most distal part of the limb should be regarded as positive proof of existing traumatic neuritis.

Acute bone atrophy plays a conspicuous rôle in the general pathology of osseous tissue. The aid of physiology and physiological chemistry is needed in solving the problem of this complex process.

BIBLIOGRAPHY

Büssem, W.: Über akute, fleckige Knochenatrophie und Trauma. Deutsche Ztschr. f. Chir., CCXXXI, 418, 1931.

Dale, Sir Henry: Chemical Transmission of the Effects of Nerve Impulses. British Med. J., I, 835, 1934.

Dejerine, J.: Sémiologie des affections du système nerveux. Paris, Masson et Cie, 1914.

Fenker: Auffallende Knochenveränderungen nach einfacher Verstauchung. Arch. f. klin. Chir., CLVI, 413, 1929.

Fontaine, R., and Herrmann, L. G.: Post-Traumatic Painful Osteoporosis. Ann. Surg., XCVII, 26, 1933.

Häbler, Carl: Physikalisch-Chemische Probleme in der Chirurgie. Berlin, Julius Springer, 1930.

Henderson, M. S., Noble, T. P., and Sandiford, Kathleen: Ununited Fractures with Special Reference to the Chemistry of the Blood. J. Bone and Joint Surg., VIII, 607, July 1926.

Heydemann, E. R.: Gesetzmässigkeiten der Knochenatrophie nach Frakturen. Beitr. z. klin. Chir., CLVII, 561, 1933.

Jones, R. Watson: Inadequate Immobilization and Non-Union of Fractures. British Med. J., I, 686, 1934.

Jones, R. Watson, and Roberts, R. E.: Calcification, Decalcification, and Ossification. British J. Surg., XXI, 461, 1933.

Kienböck, Robert: Ueber acute Knochenatrophie bei Entzündungsprocessen an den Extremitäten (fälschlich sogenannte Inactivitätsatrophie der Knochen) und ihre Diagnose nach dem Röntgen-Bilde. Wiener med. Wchnschr., LI, 1346, 1901.

König, Fritz: Über Abbau am gebrochenen Knochen, sein Wesen und seine Bedeutung. Arch. f. klin. Chir., CXLVI, 624, 1927.

Leriche, R., et Fontaine, R.: Des ostéoporoses douloureuses post-traumatiques. Presse Méd., XXXVIII, 617, 1930.

Oserov, A.: Zur Klinik der Rezidive von Pseudarthrosen bei Verletzungen u. Erkrankungen d. peripheren Nerven. Folia Neuropathologica Estoniana, III–IV, 188, 1925.

Ravdin, I. S., and Morrison, M. E.: Ossification after Fracture. An Experimental Study. Arch. Surg., XVII, 813, 1928.

Staudinger: Schwere Knochenatrophie nach kleinen Traumen. Arch. f. Orthop. u. Unfall-Chir., XXXIV, 221, 1934.

Sudeck, P.: Ueber die acute entzündliche Knochenatrophie. Arch. f. klin. Chir., LXII, 147, 1900.

Timpe, Ottfried: Untersuchungen über die Physiologie der Knochenbruchheilung. 2. Mitteilung. Das Auftreten und die Wirkung von Phosphatasen an der Bruchstelle. Deutsche Ztschr. f. Chir., CCXLI, 505, 1933.

Turner, H.: Über Nervenschädigung beim typischen Radiusbruch. Arch. f. klin. Chir., CXXVIII, 422, 1924.

Neurotrophic Disturbances of the Hand Associated with a Bite of a Cat or Colles' Fracture. J. Bone and Joint Surg., XIII, 161, Jan. 1931.

Willich, C. Th.: Über akute traumatische Knochenatrophie. Arch. f. klin. Chir., CLVIII, 287, 1930.

OLD DISLOCATIONS OF THE SHOULDER *

BY GEORGE E. BENNETT, M.D., BALTIMORE, MARYLAND

During the past twenty years much has been accomplished in the cure of recurrent dislocation of the shoulder, but little has been done to improve the treatment of acute or old dislocations or fracture-dislocations. Nothing of great interest has been added to the literature since Dollinger's masterpiece in 1911, in which he emphasized the importance of the division of the subscapularis and very minutely described the existing pathological process.

In this paper, only those cases in which reasonable and well-advised manipulative procedure has failed will be considered as cases of old or irreducible dislocation. The cases which are reported were so treated before open reduction was advised. Fracture-dislocations in which union had occurred at the site of fracture come within this group and were treated as dislocations. Acute fracture-dislocations will not be considered.

The vast majority of dislocations of the shoulder are of the anterior type and may be divided into three groups: first, intracoracoid,—cases in which the head of the bone becomes fixed between the glenoid fossa and the coracoid process; second, subcoracoid,—cases in which the head becomes fixed under the coracoid; and third, subclavicular,—cases in which the head passes beyond the coracoid. This fine differentiation has no particular bearing on the indications for arthrotomy or the operative manipulations. The posterior and subglenoid dislocation is so uncommon that no special consideration of it will be given here.

In the treatment of an old dislocation of the shoulder, there are two points to be considered: first, ultimate function; and, second, how much can be accomplished by conservative treatment,—physiotherapy. Painless adaptation and fair function in some instances have been reported. Dessaint and many of the French school have reported such cases. A patient of advanced years should not be considered as a candidate for open reduction, as some improvement in function can be obtained by physiotherapy. However, by and large, old dislocations are painful and the discomfort is not lessened by time or by physiotherapy. Many cases unsuccessfully treated by this method have also been reported. Delbet, after an extensive study, very tersely summarized his conclusions in these words: "Arthrotomy is the means, reduction is the goal, and resection is the expedient."

Because of the pain associated with an old dislocation of the shoulder, operative interference is indicated. The end results of such an operation are most satisfactory from the patient's point of view. Even though there is a limited range of motion, a shoulder in which the dislocation has

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 7, 1935.

been reduced by arthrotomy is painless and much more useful than it would have been if a resection had been done, especially if the shoulder were damaged to the extent usually found in an old dislocation.

The operation has always been considered difficult, but there are two or three points which, if recognized, lessen the difficulties in accomplishing the desired reposition of the humerus into the glenoid fossa. The surgeon should use the incision with which he is most familiar, but most surgeons prefer the anterior incision which opens the operative field between the margin of the deltoid and the pectoral muscles. In some cases, the fibers of the deltoid muscle have been separated. In the author's opinion, this allows the glenoid fossa to be cleared out more easily than does the extreme anterior incision. If one is handicapped by lack of sufficient space with the use of the straight anterior incision, then the incision may be continued anteriorly along the margin of the clavicle. By this means, the pectoral fibers are freed and more exposure toward the midline is obtained. The incision may also be extended posteriorly along the margin of the deltoid and its attachment to the acromion. Through this exposure, the pathology is at once apparent. The supraspinatus, infraspinatus, and teres minor, and the capsule are drawn across the glenoid fossa, obliterating the normal space. The muscles and tendons are fibrosed in proportion to the amount of trauma sustained at the time of injury and the length of time which has elapsed since the dislocation. In a great many cases, the tuberosities, with their muscle attachments, are also torn free.

It seems to the author that one of the most important steps in the operation is the clearing of the glenoid fossa, so that after the subscapularis has been cut, which allows external rotation and delivery of the head, there is sufficient space in or about the glenoid to enable reposition to be made.

Cubbins has expressed the opinion that the biceps tendon is responsible for the difficulty in reducing a dislocation of the shoulder. In only two cases in the writer's experience has the biceps tendon interfered with reduction. The biceps is often very badly damaged, particularly in those cases where there was a fracture of the tuberosity at the time of the dislocation. In many instances, the biceps is severed and the distal end of the tendon will be found adherent to the humerus in the region of the fracture.

The author believes that one of the most serious obstacles in the way of obtaining a stable, movable shoulder is the manufacturing of an anterior portion of the capsule. This portion is usually so badly destroyed by the original dislocation and subsequent atrophy that very little of it can be reclaimed, and, at the outset of exploration, every effort should be made to conserve, in so far as possible, the structures about the anterior portion of the shoulder joint, so that the anterior capsule may be reconstructed. It is quite possible at times to detach the supraspinatus and to transplant it into a more forward position. On many occasions, the author has been

obliged to resort to plastic operations, using fascia lata. In one or two cases, the long head of the biceps was implanted into the head of the humerus, and, in one case, the coracobrachialis and the long head of the biceps were transferred to a short portion of the anterior capsule. In other words, there is no orthodox method for the reconstruction of the ligaments about the shoulder and one has to resort to any means possible in order to obtain this. Of course, it is quite often impossible to subject an elderly patient to a long period of anaesthesia and, therefore, a new anterior portion of the capsule cannot be manufactured. Such a case invariably results in a slight anterior luxation of the shoulder when the arm is abducted. However, even with this apparent deviation from the ideal, the result of this operation is a painless shoulder with a fair range of abduction.

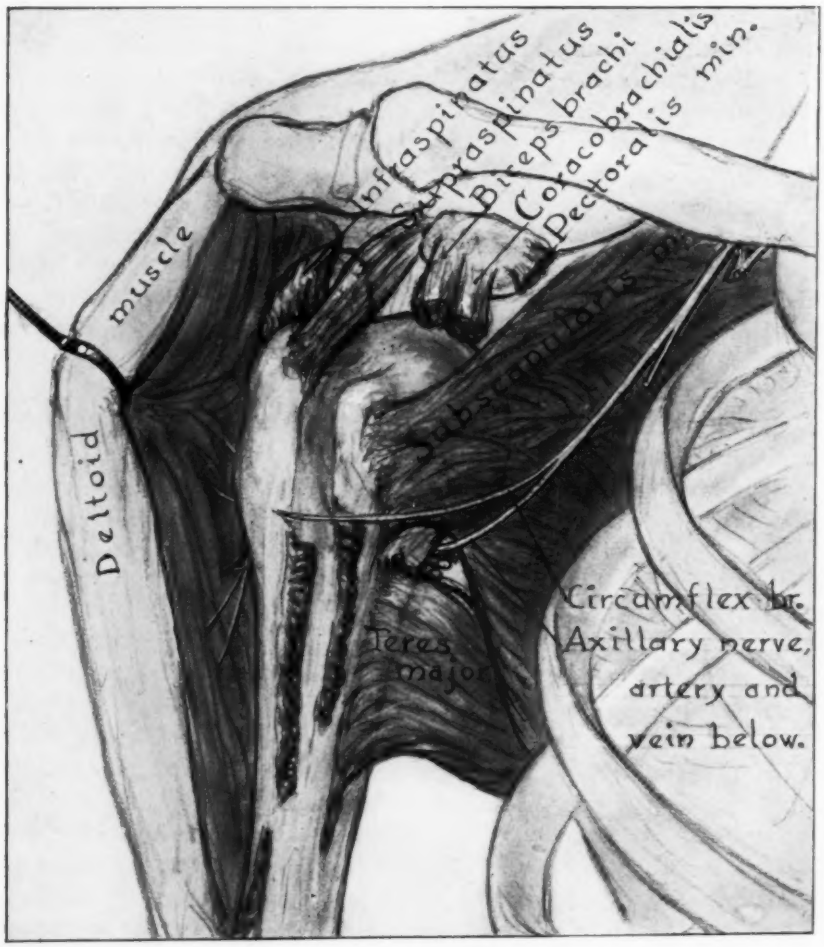


FIG. 1

Showing position of circumflex and axillary nerves.

Too much stress cannot be placed on the importance of the cutting of the subscapularis. Many times it has been found necessary to divide the tendon of the pectoral muscle before the head of the humerus could be delivered from its lodging place about the coracoid process.

The writer has found that the most satisfactory position in which to maintain the head of the humerus near its normal position is that of the so called position of salute,—the arm abducted to about 80 degrees and the humerus looking forward. This produces a direct posterior pressure and forces the head backward, relaxing the tissues about the anterior portion of the shoulder joint. This position is maintained for a period of between four and six weeks and is followed by physiotherapy.

What is to be expected as an end result of an old and irreducible dislocation of the shoulder after such a mutilating operation? In most cases, the axillary nerve is injured by the original dislocation and the malposition of the head of the humerus over a period of months, and not infrequently it is probably injured during the time of operation, so that, in a great many old dislocations, a weakness, but not a complete paralysis, of the deltoid is the end result, which impairs the movement of the shoulder in abduction.

If one analyzes the results obtained, it will be found that better function can be expected in the early cases. There is a much better chance of securing normal function in a shoulder in which reduction was obtained within the first month or six weeks after the injury than in a shoulder in which reduction was accomplished six months after the injury. Some very unusual cases have been reported in which supposedly normal function has been obtained in old dislocations of the shoulder, but the author's experience has been that the sooner the operation is performed the better the function which is obtained. The writer believes that if 45 degrees of voluntary abduction is secured in an old dislocation of the shoulder, in which the head of the humerus has been in malposition over a period of six months, the result is very satisfactory.

The points which have been mentioned are based on the author's experience with approximately twenty cases of old irreducible dislocation of the shoulder. It has been possible to collect satisfactory records of only fourteen cases, as a number of these patients were operated upon in small rural hospitals where the records are incomplete or the case histories have been lost and accurate notes are not obtainable.

CASE REPORTS

CASE 1. M. S., a female, aged thirty-seven years, was admitted on December 12, 1922. Seven months prior to admission, the patient had sustained a fracture-dislocation of the right shoulder and a fracture of both bones of the forearm. The fracture of the upper third of the humerus had been allowed to heal, but the dislocation of the shoulder had not been reduced. Neurological examination confirmed the clinical opinion of a paralysis of the deltoid, probably the result of an injury to the axillary nerve.

An arthrotomy of the shoulder was performed through the anterior incision between the inner margins of the deltoid and pectoral muscles. The glenoid fossa was cleared of

a mass of fibrous tissue; the subscapularis was divided; and the head of the humerus was dislodged from beneath the subcoracoid process and delivered into the glenoid fossa. The biceps tendon was very markedly frayed. Only a small portion of the anterior part of the capsule could be reclaimed, and the tendon of the coracobrachialis and the biceps was fastened to the short portion of the anterior part of the capsule, thus reenforcing the capsule at this point. The arm was placed in the salute position of abduction, the head of the humerus looking forward.

In view of the fact that the patient apparently had a complete paralysis of the deltoid, the head of the humerus was partly scarified and the arm was maintained in a position of abduction for a period of two months, as a fibrous ankylosis was considered desirable.

The patient made an uneventful recovery. Although function in the deltoid has not been recovered, the patient has an active, useful arm with 60 degrees of abduction, but no free motion in the shoulder joint.

CASE 2. G. T., a male, aged forty years, was admitted on July 1, 1925. The patient had sustained a dislocation of the left shoulder five weeks previously. An attempt at reduction under anaesthesia was unsuccessful.

At operation, through the anterior incision, the shoulder was explored. The glenoid fossa was cleared of fibrous tissue and the tendons of the supraspinatus and infraspinatus muscles were severed. The head of the humerus was palpated beneath the coracoid process. Several exostoses were noted about the margin of the head and were removed, after which the subscapularis was divided. By external rotation, the head of the humerus could be delivered, but was obstructed by the biceps tendon which was then divided. The head of the humerus was replaced in the glenoid fossa and the anterior capsule was repaired, utilizing the tendon of the biceps as a reenforcement of the anterior part of the shoulder joint. The arm was placed in a plaster-of-Paris dressing in abduction of about 45 degrees and slightly forward.

The patient was examined a few weeks after operation, but the writer has been unable to communicate with him since that time and the end result cannot be reported.

CASE 3. Mrs. J. S., aged fifty-six years, was admitted on August 19, 1927. Three weeks prior to admission, the patient had fallen and had injured the right shoulder. Both physical and roentgenographic examinations showed a fracture-dislocation of the right shoulder.

The author was of the opinion that sufficient union had occurred at the site of fracture to justify an attempt at reduction at this time. Under anaesthesia, manipulation was done without success. An arthrotomy was then performed and, with very little difficulty, the head of the humerus was dislodged from beneath the subcoracoid process. The fragments, however, became disengaged at the line of fracture and were wired into position after reduction.

The patient made an uneventful recovery. One year after operation, she had 80 degrees of abduction, with no evidence of any paralysis of the deltoid.

CASE 4. A. P., a male, aged twenty-five years, was admitted on May 26, 1929. Three years previously, the patient had dislocated both shoulders during a convulsive seizure associated with a meningitis. No attempt at reduction had been made.

Physical examination showed a rather unusual atrophy of the supraspinatus and infraspinatus muscles of both shoulders with a distinct depression and flattening posteriorly. There was very little motion between the head of the humerus and the coracoid process, but the scapulae had compensated for this lack, so that there was external rotation, but very little internal rotation.

The author informed the patient that he was not sure he could accomplish a reduction at this late date. The arm was put in traction over a period of several days in order to stretch the muscles about the shoulder joint.

On June 13, 1929, the shoulder was explored through the anterior incision. It was

not possible to identify either the supraspinatus or the infraspinatus muscle. The glenoid was cleared of a mass of fibrous tissue. The cartilaginous surface of the glenoid was considerably damaged. The subscapularis tendon was divided and, with great difficulty, the head of the humerus was dislodged from its resting place beneath the coracoid process and placed in the proximity of the glenoid fossa. A complete reduction could not be obtained. An attempt was made to repair the anterior capsule, but there was very little available tissue. The arm was placed in a few degrees of abduction and slightly forward.

Five years after operation, there was no free motion in the shoulder joint, but there was about 30 degrees of abduction due to scapular movement. When compared with that of the opposite shoulder, function had not been improved.

The author was very doubtful before the operation that he could improve the condition of the shoulders in this case, but the patient and his family were very anxious to see if something could be done. The case is reported as a failure as the patient does not feel that he has been benefited in any way. This is the only case of this type reported in this series.

CASE 5. A. M., a male, aged sixty-four years, was admitted in March 1931. Seventeen months previously, the patient had dislocated the right shoulder. On admission, he complained of loss of function of the arm, and of discomfort.

Examination revealed a subcoracoid dislocation of the shoulder, with marked restriction of motion. Attempted manipulative reduction was unsuccessful.

An open operation was then performed, in which the anterior deltoid incision was used. The head of the humerus was found in the subcoracoid position. The capsule was not identified. The glenoid fossa was found to be filled with scar tissue which was carefully removed. Attempts at moving the head of the humerus at this stage, after the division of the subscapularis, were not successful. On further search, an exostosis was found in the region of the greater tuberosity, which seemed to prevent reduction. This exostosis was removed and the head was levered into the glenoid. The arm was placed in a plaster Velpeau bandage.

The patient was seen four weeks after operation. He then disappeared and a final check-up cannot be obtained.

CASE 6. M. H., a female, aged sixty years, was admitted on April 29, 1931. Seven months prior to admission she had fallen and had dislocated the right shoulder.

Examination revealed an old subcoracoid dislocation of the shoulder. An attempted closed reduction under anaesthesia was unsuccessful.

At operation, April 30, 1931, there was present the usual condition of obliteration of the glenoid fossa by a mass of fibrous tissue and the atrophied tendons of the supraspinatus and infraspinatus muscles. The glenoid was cleared of fibrous tissue and as much of this tissue as possible was reclaimed. The head of the humerus was identified beneath the coracoid process; the subscapularis was divided; and, with very little difficulty, the head of the humerus was replaced in the glenoid fossa. The arm was fixed in abduction.

Four years later, examination showed 70 degrees of free motion in abduction, elevation of the arm to a right angle, and a slight weakness of the deltoid. The shoulder is painless, and function is satisfactory.

CASE 7. K. M., a female, aged sixty years, was admitted on May 13, 1932. Two months prior to admission, the patient had sustained a dislocation of the left shoulder. Attempts at reduction had been unsuccessful.

Examination showed a typical subcoracoid dislocation of the shoulder.

Exploration of the shoulder, through the anterior incision, disclosed that the glenoid fossa was filled with old blood clots and semifibrous tissue. The supraspinatus and

infrapinatus muscles were identified and freed from their attachments about the tuberosities. The head of the humerus was then identified in a subclavicular position, having passed beyond the coracoid process. With a great deal of difficulty, the humerus was freed from this position; the subscapularis was divided; and reduction was obtained. The patient was very shocked by the operation and time did not permit the manufacturing of an anterior portion of the capsule of the joint.

Three years later, examination showed that the patient had about 40 degrees of voluntary abduction, but the arm could be passively abducted to 90 degrees.

The patient is well satisfied with the end result, although there is considerable relaxation of the anterior part of the shoulder joint.

Case 8. T. H., a female, aged fifty-nine years, was admitted on April 28, 1933, suffering from an old dislocation of the shoulder of five months' duration. Reduction by manipulation had been attempted without success. The patient complained of pain and discomfort, and an inability to use the arm.

An operation was performed on April 29, 1933, through the usual anterior incision, by the resident surgeon who stated that he had succeeded in getting the head of the humerus in or about the glenoid fossa. Roentgenograms, made one week later, however, showed the shoulder to be dislocated.

The author expressed the opinion that the head had not been replaced in the glenoid fossa, and an exploratory operation was done on May 23, 1933, which confirmed this opinion. The glenoid fossa was cleared of a fibrous mass and the head of the humerus was replaced.

Examination, about two years after the operation, showed only about 40 degrees of voluntary abduction, although the shoulder could be passively abducted to about 90 degrees. There was quite a marked limitation of internal and external rotation and a moderate relaxation of the anterior portion of the capsule.

The patient has a useful, painless arm and is very well satisfied with the result.

Case 9. E. B. F., a male, aged sixty-two years, was admitted on July 24, 1933. Six weeks prior to admission, the patient had sustained a subcoracoid dislocation of the shoulder, which had not been recognized. Manipulative reduction was attempted, without success. The arm was then placed in continuous traction for a period of forty-eight hours and a second attempt at reduction was made, also without success.

On August 1, 1933, an open operation was performed through the usual anterior incision, and the head of the humerus was located beneath the coracoid process. The glenoid fossa was cleared of fibrous material and the subscapularis was divided. An attempt was made to deliver the head of the humerus, and, during this procedure, the humerus was fractured just below the tuberosity. This in no way interfered with the reduction. The patient's condition was such that it was impossible to reenforce the anterior part of the capsule of the joint. The arm was placed in a plaster dressing in the salute position.

Examination, eighteen months after operation, showed that the patient had a very marked weakness of the deltoid. The head of the humerus was slightly forward and downward.

There is a marked weakness of the deltoid with only about 30 degrees of voluntary abduction. The shoulder is painless and the patient states that he is very well satisfied with the end result.

Case 10. J. P., a male, aged fifty-eight years, was admitted on October 29, 1933. Six months prior to admission, the patient had been operated upon by Dr. Dandy for removal of a brain tumor. Neurological signs had persisted after his return home and, during an attack, he had fallen and had dislocated the right shoulder.

An attempt at reduction was unsuccessful. The patient presented the typical picture of a posterior dislocation of the shoulder. Under anaesthesia, the shoulder could be reduced, but would immediately slip back into the posterior position. Exploration

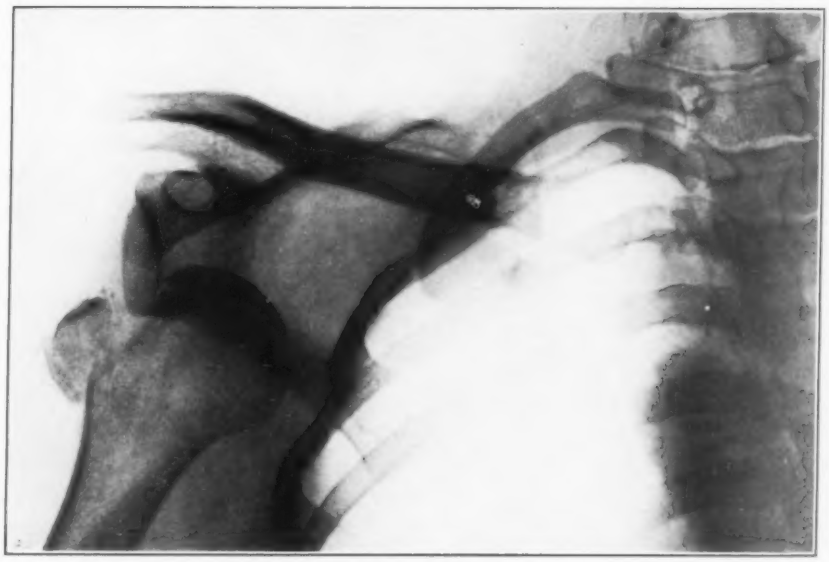


FIG. 2

Case 12. B. G., aged fifty years. Subcoracoid dislocation of shoulder with fracture of tuberosities of four weeks' duration.

disclosed that the biceps tendon had been torn free from the bicipital groove and was acting as an obstacle in the reduction of the shoulder. The tendon was divided and the Nicolai type of operation for fixation of the head was done.

A few days after the operation the patient became totally disoriented and he died eight

FIG. 3

Case 12. B. G. Three weeks after reduction.

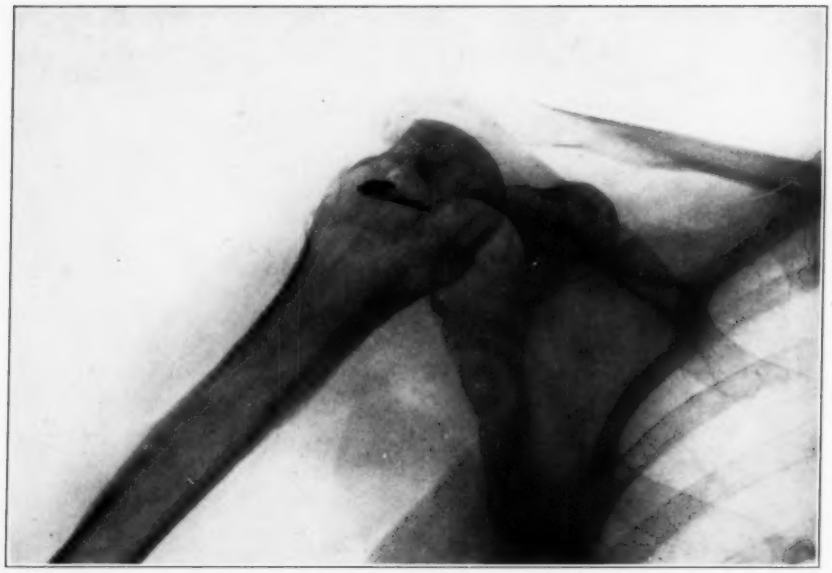


FIG. 4

Case 12. B. G. Fourteen months after operation. Voluntary abduction of 45 degrees. Painless shoulder. Axillary nerve injured in original dislocation.

days after the operation. It was felt by all concerned that the operative procedure had nothing to do with the patient's death.

This case is one of the few instances in which the long head of the biceps acts as a factor in preventing the reduction of a dislocation of the shoulder.

CASE 11. J. T. D., a male, aged fifty years, was admitted on July 8, 1934, with a typical subcoracoid dislocation of the left shoulder. On July 13, 1934, the author attempted manipulative reduction under anaesthesia, which was unsuccessful.

On July 20, 1934, approximately one month after the injury, an open reduction of the shoulder was done. Fascial sutures were used in order to repair the anterior part of the capsule. The patient developed an infection.

Examination, made on February 13, 1935, showed a relaxation of the anterior part of the capsule. The deltoid was strong, and there was voluntary abduction of 60 degrees. The patient stated that motion was gradually increasing.

The patient now has a shoulder that functions well.

This is a case of a relaxation of the anterior part of the capsule following unsuccessful repair and slight infection.

CASE 12. B. G., a female, aged fifty years, was admitted on February 12, 1934. One month prior to admission, she had fallen and had dislocated the left shoulder.

Manipulative reduction was unsuccessful and, on February 23, 1934, an arthrotomy was performed through an anterior incision. The greater tuberosity, with its muscle attachments, was found to be free. The glenoid fossa was cleared of a fibrous-tissue mass and the shoulder was reduced without division of the subscapularis. The greater tuber-

FIG. 5

Case 13. M. S., aged forty-one years. Subcoracoid dislocation of shoulder of three months' duration, following manipulation for adhesions of shoulder.

FIG. 6

Case 13. M. S. One year after operation. Weakness of deltoid gradually improving. Voluntary abduction of 50 degrees. Passive abduction to 80 degrees.

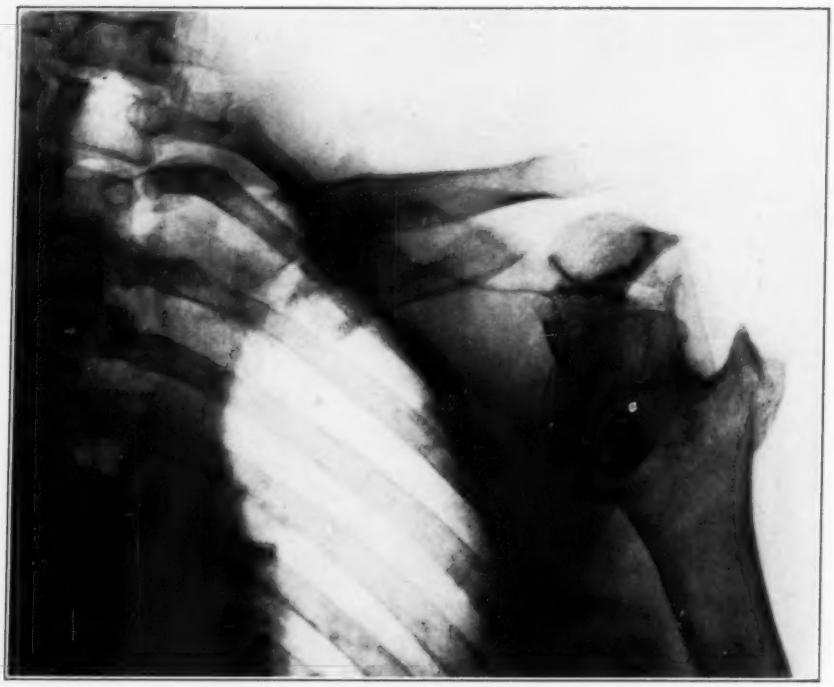


FIG. 7

Case 14. A. A., aged sixty-two years. Subcoracoid dislocation of shoulder with fracture of the tuberosities. Seventeen months after injury.

FIG. 8

Case 14. A. A. Two months after reduction. Patient has voluntary abduction of 40 degrees.

osity was fixed in place with a small nail. The arm was placed in a slightly forward and abducted position.

The patient made an uneventful recovery. Examination, fourteen months after the operation, showed voluntary abduction of 45 degrees with passive abduction of 80 degrees. There was good power in the anterior and posterior portions of the deltoid, but the midsection of the deltoid seemed weakened.

The patient states that she has a painless and useful arm and is very well satisfied with the end result.

CASE 13. M. S., a male, aged forty-one years, was admitted on May 13, 1934. Eight months previously, he had injured the right shoulder. He continued to have discomfort for several weeks. About three months before he was seen by the author, the patient had been given a general anaesthetic and the shoulder had been manipulated for the release of adhesions. Manipulation did not improve the condition, — the arm remained persistently painful with marked loss of function.

On admission, physical examination showed considerable atrophy in the region of the deltoid. Roentgenographic examination revealed a typical subglenoid dislocation of the humerus.

On May 14, 1934, an operation was performed through the anterior incision. The glenoid fossa was cleared and the supraspinatus muscle was detached from the tuberosity. The subscapularis was divided, and reduction was accomplished. The arm was placed in a Velpeau bandage in a few degrees of abduction.

A recent examination showed a moderate weakness of the deltoid with about 65 or 70 degrees of voluntary abduction. The shoulder is painless and function is very satisfactory. The condition is gradually improving.

The author assumes that the dislocation occurred at the time of manipulation and not at the time of original injury, eight months before the date of operation. Therefore, this case is listed as a dislocation of three months' duration.

CASE 14. A. A., a male, aged sixty-two years, was admitted on March 27, 1935. Seventeen months previously, he had fallen and had injured the right shoulder. He consulted a "bone-setter" who manipulated the arm.

Physical examination showed a typical subcoracoid dislocation, with a flattening of the shoulder joint, but with a good functioning deltoid. Roentgenographic examination disclosed a very marked deformity anterior to the greater tuberosity, with excess bone formation at this point.

At operation, through the anterior incision, the thickened area about the greater tuberosity was partially removed, and the tendons of the supraspinatus and infraspinatus were freed. A rather thick, firm mass of fibrous tissue was removed from the glenoid fossa. The head of the humerus was identified beneath the coracoid process. The subscapularis and the tendons of the pectoral muscle were divided before the head could be rotated from its resting place. Reduction was obtained and a surprisingly good anterior portion of the capsule was reconstructed with the tendons of the supraspinatus and the remaining portion of the capsule. The arm was placed in a Velpeau bandage in the salute position.

Six weeks after operation there was good power in the deltoid and about 40 degrees of voluntary abduction. The shoulder is painless and the patient seems very well pleased with the result.

SUMMARY

In cases of old dislocation of the shoulder, operation is indicated for restoration of function and relief of discomfort.

Operation is advised in all early cases. In the older cases, in which

the shoulder has been dislocated for several months and there is painless adaptation with 50 degrees of free movement, operation is not advisable. Experience has shown that the end result in these cases is seldom perfect function of the shoulder with a free range of motion. In most instances the free movement obtained is in proportion to the duration of the dislocation. The early cases are much more successful.

Weakness of the deltoid is present in a large percentage of cases following operation. This may be due either to the original injury or to operation, as the nerve supply to the deltoid may be easily damaged by the division of the subscapularis muscle.

The first step in the operation, in the author's opinion, is the clearance of the glenoid fossa and the division of the subscapularis muscle, but the most difficult step is the reconstruction of the anterior portion of the capsule. This may be accomplished by utilizing the long head of the biceps, as described by Nicolai in his treatment for recurrent dislocation of the shoulder, or by reenforcing the anterior part of the capsule with fascial sutures. In one or two instances the writer has transferred the tendon of the coracobrachialis and the long head of the biceps and attached them to the short superior portion of the capsule, thus reenforcing the anterior part of the joint. While operation for an old dislocation of the shoulder may not result in 100 per cent. function, it is much more satisfactory than a resection of the head of the humerus for the same condition.

REFERENCES

Cubbins, W. R., Callahan, J. J., and Scuderi, C. S.: Reduction of Old or Irreducible Dislocations of the Shoulder Joint. Surg. Gynec. Obstet., LVIII, 129, 1934.

Delbet, Pierre: Des luxations anciennes et irréducibles de l'épaule. Arch. Gén. de Méd., I, 19, 144, 1893.

Dessaint, J. J.: Sur l'adaptation fonctionnelle dans les luxations anciennes antéro-internes de l'épaule. Rev. d'Orthop., XV, 508, 1928.

Dollinger, Julius: Die veralteten traumatischen Verrenkungen der Schulter, des Ellenbogens und der Hüfte. Ergebn. d. Chir. u. Orthop., III, 83, 1911.

RECONSTRUCTION OF THE DIGITAL TENDON SHEATH

A Contribution to the Physiological Method of Repair of Damaged Finger Tendons *

BY LEO MAYER, M.D., NEW YORK, N. Y.

Attending Orthopaedic Surgeon, Hospital for Joint Diseases

AND NICHOLAS RANSOHOFF, M.D., NEW YORK, N. Y.

Associate Orthopaedic Surgeon, Hospital for Joint Diseases

Through the researches of Biesalski, Henze, and Mayer it has been proved that adhesions to transplanted tendons can be prevented most effectively by avoiding trauma to the gliding mechanism of the tendon. This mechanism consists partly of the sheath, partly of the paratenon (the loose gliding tissue which intervenes between the tendon and the rigid fascia), and finally of the smooth, gliding cells on the surface of the tendon. Damage to any portion of the gliding mechanism is likely to result in the formation of an adhesion which prevents the motion of the tendon. In operating on paralyzed limbs where normal tendon sheaths are available, it is possible in almost all instances to minimize the formation of postoperative adhesions by running the transplanted tendon through the sheath of the paralyzed tendon. If the operator exercises a reasonable degree of care and does not damage the delicate, gliding cells on the surface of the tendon or on the corresponding smooth inner wall of the tendon sheath, a free, gliding motion comparable with the normal usually results. In a check-up of over 400 tendon transplantations done for paralytic conditions, the authors found approximately 90 per cent. of good or excellent results.

In dealing with traumata to the finger tendons, however, conditions are quite different and the results of tendon transplantations have been extremely disappointing. The reason for this is evident when one considers the pathological changes which occur after a division of the flexor tendons of the fingers. Even if no infection occurs, adhesions form which bind the distal stumps of the flexor digitorum sublimis and the flexor digitorum profundus tendons to one another and to the inner wall of the tendon sheath (Fig. 1).

These adhesions extend from the point of division of the tendons down to the distal end of the digital theca. They destroy the smooth cells on the surface of the tendon and the sheath. The proximal tendon stumps retract, leaving a gap of several inches between them and the distal stumps. Like the distal stumps, they become bound to one another by adhesions, but these rarely extend proximally for more than one inch.

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 14, 1936.

The gap between the tendon ends is filled with scar tissue which replaces the tendon sheath. It is obvious that the normal gliding mechanism of the tendon has been completely destroyed and that, consequently, the conditions for reestablishing free gliding of a transplanted tendon are so unfavorable that only in exceptional instances can an implanted tendon perform its normal function.

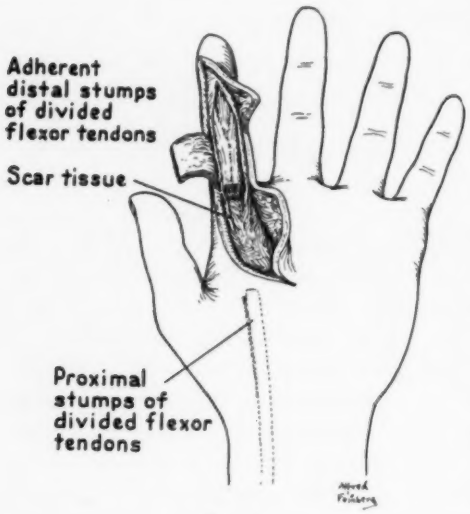


FIG. 1

Pathological conditions found when the flexors of the index finger have been severed near the metacarpophalangeal joint. Note the scar tissue binding the tendons to one another, destroying the tendon sheath, and filling the gap between the tendon stumps.

If a mild infection has occurred, the adhesions are denser, and the degree of damage increases with the severity of the infection.

Despite the cases reported by Bunnell, Koch, Cleveland, and a few others, the percentage of satisfactory results has been so low that experienced surgeons hesitate to undertake the operation, and the insurance companies, who cast a critical eye on results, refuse to endorse it.

For the past four years the authors have been trying to improve the technique of tendon transplantations for damaged fingers. It seemed to us that if there were a possibility of reconstructing a smooth-walled tendon sheath to replace the scarred one, there would then be a possibility of implanting a new tendon and retaining its gliding function. One of us (N. R.) called attention to the work of Prime of the Columbia College of Physicians and Surgeons. Prime pursued his investigations under the direction of Dr. William Clark and made a systematic attempt to find out a method of preventing adhesions following operations on the brain. He discovered that chemically pure celloidin did not produce the typical foreign-body reaction, but that the surface of the celloidin became coated with smooth tissue whose flattened cells resembled those lining the wall of the tendon sheath. At that time Prime had made no mention of the possible application of this fact to tendon surgery. Animal experiments, in which the authors implanted tubes of chemically pure celloidin surrounding the Achilles tendon of a rabbit, confirmed Prime's results and indicated that a sheath could be built up around the tendon which in many respects resembled the normal lining of the tendon sheath. The exact mode of application to damaged finger tendons was for many months so puzzling as to baffle us. Many plans were tried and were

unsuccessful, but finally the following procedure was devised and has given sufficient success to warrant publication.*

PREPARATION OF CELLOIDIN TUBES

First, it was necessary to make celloidin tubes of varying sizes corresponding to the tendon sheaths of different hands. These celloidin tubes had to have perfectly smooth surfaces, since, if any roughness were present, the characteristic smoothness of the tissue enveloping the tube would be lacking. After experimenting with numerous methods, we were compelled to follow the slow-evaporation method, since it alone gave us tubes of satisfactory smoothness and hardness. A thick solution of chemically pure celloidin (pyroxylin, guncotton) is made by dissolving it in acetone. The solution is poured slowly into test tubes of varying sizes. We have found three sizes to be sufficient. The diameters of the tubes used are as follows: large, one centimeter; second size, eight-tenths of a centimeter; small, six-tenths of a centimeter.

The pouring must be done very slowly, so that air bubbles do not accumulate in the tube. The tubes are placed upright in an incubator at 37 degrees, centigrade, and allowed to evaporate very slowly. This gets rid of any remaining air bubbles. As the acetone evaporates and the level of the fluid becomes lower, additional solution is added in order to keep the test tubes filled to the brim. This process must be repeated about once a week during the first three months; evaporation is usually complete at the end of four or five months. When on inspection of the test tubes the celloidin seems to be sufficiently hard, the test tube is broken with a gentle blow of a hammer and the celloidin tube can then be removed. The outside diameters of the completed tubes correspond to the inside diameters of the test tubes used.

The celloidin tubes are kept in a solution of distilled water until the time of the operation. They are then sterilized by immersion in a 1 to 2000 solution of oxycyanate of mercury just as is employed in sterilizing a cystoscope. The immersion should not last longer than twenty minutes. In our first attempts at sterilization, the tubes were left in for several hours and their surface then showed a greenish scum, evidently due to dialysis of the mercury solution. This destroyed the smoothness of the celloidin tube and interfered with the smoothness of the enveloping tissue.

OPERATIVE TECHNIQUE

The operation is done in two stages. The first consists in a complete resection of the scarred tendon sheath and damaged tendons and the implantation of the celloidin tube. This tube must reach from the proximal stumps of the tendon down to the distal attachment of the flexor profundus at the base of the distal phalanx. The incision for this extensive

* A preliminary report of the celloidin-tube method was published in the January 1936 issue of *The American Journal of Surgery*.

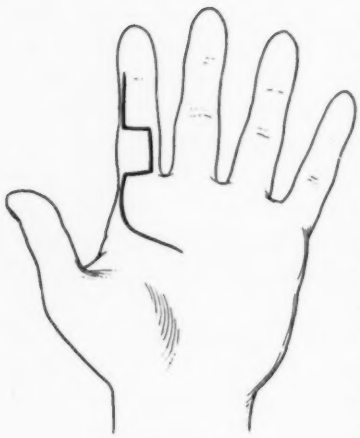


FIG. 2

Typical incision for first stage of the operation in a case of divided flexor tendons of the index finger. The incision follows the normal creases of the palm and fingers.

operation should follow the normal creases of the palm and fingers. Bunnell has shown that keloid formation can be avoided if incisions do not cross the creases at a right angle. Figure 2 indicates the type of incision which has been used most frequently. Slight variations from this general plan have to be made to suit each patient. The skin and subcutaneous tissues are dissected back with particular care to avoid damage to the sensory nerves. When the finger itself is being worked on, the palmar flap should be made as thick as possible, since this will serve to cover the celloidin tube more effectively and will eventually help to replace the normal vincula and thus act to hold the tendon against the phalanges. All of the scar tissue is carefully removed by sharp dissection. The distal portions of both the flexor sublimis and the flexor profundus tendons are excised. If possible, a half-inch stump of the flexor profundus tendon is left to serve as an anchorage for the tendon graft to be implanted at the second operation. The proximal stumps of the flexor sublimis and the flexor profundus are then located and the elasticity of their muscles is investigated. In some instances, when many months have intervened between the accident and operation, the muscles of the damaged finger have become so atrophic and shrunken that there is practically no elasticity left in their fibers. If this fact is elicited at the time of the first operation, it simplifies the plan for the second stage. The celloidin tube is next implanted (Fig. 3). It occupies the space left by the resection of the tendons and the scarred sheath. It is held in place proximally by a single stitch taken through it and the proximal stump of the flexor profundus tendon in such a way as to hold the tendon within the tube; it is attached distally by a second similar stitch which anchors the distal

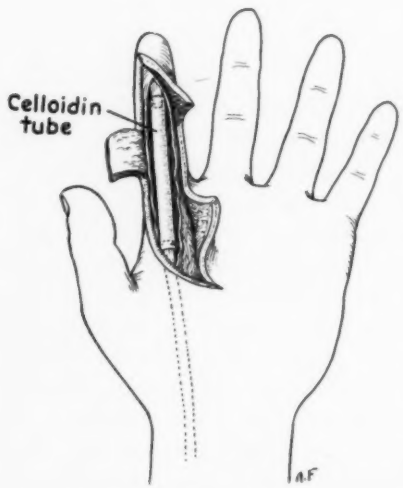


FIG. 3

Implantation of the celloidin tube after excision of scarred tissue. The tube is held in place with two stitches passing through the proximal and distal stumps of the flexor profundus tendon.

stump of the flexor profundus tendon within the tube. The authors have attempted various methods of avoiding a long incision by tunneling and undercutting, but thus far have not found any method which gives as adequate an exposure as the one described. When the tube is in place, the subcutaneous tissues are united over it by a series of fine interrupted stitches. There must be a complete covering of the celloidin tube by this process. Finally, the skin is also united by fine interrupted stitches, great care being taken to secure accurate approximation of the skin edges. A light splint, usually of plaster-of-Paris, is then applied so as to give fixation to the finger which has been operated upon.

The second stage is performed from four to six weeks after the first. A longer period of immobilization might seem advisable, but is accompanied by the danger of increasing the stiffness of the finger joints, which must of course be avoided. The plan of the second operation depends upon the condition of the muscles as ascertained at the first operation. If the muscles of the damaged tendons are in good condition, the operation is done as follows: A two-inch palmar incision is made approximately at the level of the proximal stumps of the divided tendons (Fig. 4). The incision is deepened to the level of the celloidin tube and the proximal tendon stumps are lifted out of the tube. A second incision is then made near the tip of the injured finger. This consists of a short transverse incision in the distal crease of the finger and a half-inch vertical prolongation along the side of the finger, thus making a short L-shaped incision. As the subcutaneous tissues are dissected away, the distal portion of the celloidin tube becomes visible. Within it lies the stump of the flexor profundus tendon. This is lifted out of the tube and a probe, threaded with a silk guide suture, is passed through the length of the celloidin tube and out in the region of the proximal tendon stumps. The celloidin tube is then grasped with a clamp and gently withdrawn from the finger, leaving the guide suture in place. In every instance the tube has been found completely enveloped by a smooth, glistening membrane whose surface closely resembles the normal lining of a tendon sheath. Within the tube is usually found a small quantity of clear straw-colored fluid, similar in appearance and consistency to the secretion of the normal tendon sheath. The operator then returns to the palmar incision and frees the proximal stump of the flexor profundus until normal tendon is visible. As a rule, the stump is scarred for approximately one inch. A No. 2 Deknatel silk

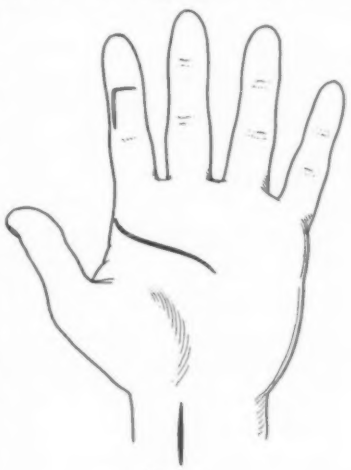


FIG. 4

Incisions for the second stage of the operation in a case of division of the flexor tendons of the index finger. As in the first stage, the incisions follow the normal creases. The incision above the wrist may be made transverse or vertical.

stitch is then inserted, beginning three-eighths of an inch proximal to the level of normal tendon. The stitch used is that already described by Bunnell and Mayer in previous communications. Figure 5 indicates the manner in which the stitch is inserted. Two small cambric needles, preferably with calyx eyes, are threaded with a ten-inch length of silk. The operator notes carefully that level of the tendon where its surface is covered with normal gliding cells, and inserts the first needle horizontally, three-eighths of an inch proximal to this point. The scarred tip of the tendon is grasped with a tendon clamp to facilitate passing the needle with minimal trauma. The same needle is then reinserted into the tendon, this time obliquely in a distal direction at an angle of about 45 degrees, so as to emerge on the opposite side of the tendon. The points of exit and entry of the needle must be as close together as possible so as not to leave silk exposed on the surface of the tendon, since this would tend to form adhesions. The needle is then reinserted a third time, also at a 45-degree angle, and is brought out close to that level of the tendon which the operator has previously noted as the termination of normal tendon tissue. With the second needle two stitches are taken at an angle of 45 degrees. These stitches cross the first series, and emerge at a point 180 degrees opposite the first. The traumatized tip of the tendon is cut off horizontally with a sharp knife just distal to the emergence of the silk sutures. The surface of the tendon should then show a normal cross-section. The two needles are removed and the silk strands are pulled taut, in order to take in all the slack. As this is being done, the silk, emerging from the sides of the tendon, will be seen to force its way between the tendon fibrils, so as to emerge near the center of the tendon. When this stitch has been properly inserted, no silk should be visible on the surface of the tendon, the two free ends should emerge near the center of the cross-section, and the operator should be able to exert at least five pounds of traction on the silk without causing it to tear out of the tendon.

If the distal stump of the profundus tendon is three-eighths of an inch long, it is suitable for the distal anchorage of the transplanted tendon and a corresponding stitch should be inserted into it. If, however, the distal stump is too short, a small drill hole must be passed through the base of the distal phalanx. In some cases the authors have used a drill hole passed in an anteroposterior direction; in others, a drill hole in a lateral direction has been employed. It is not easy to drill these holes without trauma and, for that reason, whenever possible, direct attachment to the tendon stump is a preferable procedure.

The next step is the implantation of a free tendon graft. The operator has a choice of various tendons, but, as a rule, the one best suited is the proximal intact portion of the flexor sublimis of the injured finger. One stump of this has already been exposed in the palm. The proximal portion of the tendon is easily exposed by a one-inch incision placed just above the wrist. When slight traction is exerted on the tendon in the palm, it can be identified above the wrist. It is freed in the palm by

FIG. 5

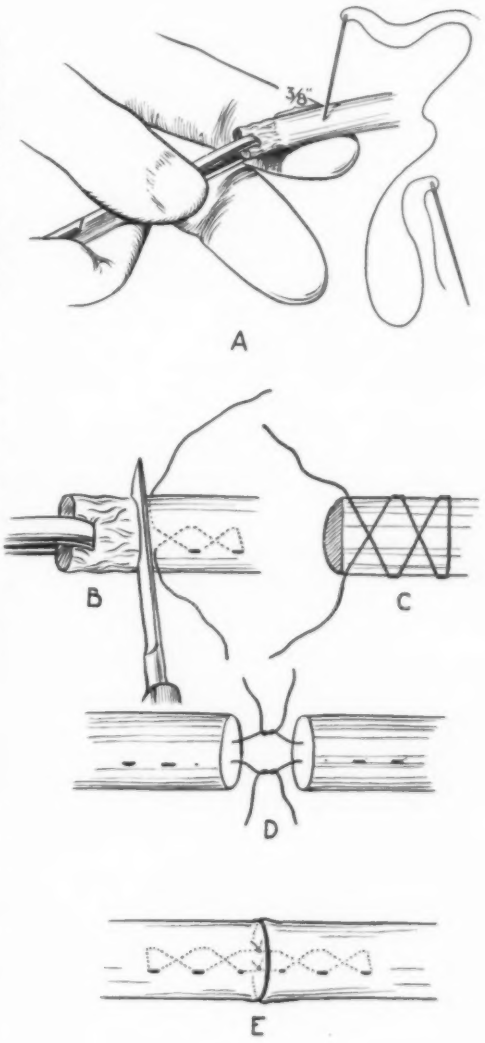
A: Insertion of the tendon stitch into the flexor profundus tendon. The scarred tip of the tendon is grasped with a tendon clamp, and the needle, threaded with No. 2 Deknatel silk, enters the tendon three-eighths of an inch proximal to the scarred portion of the tendon.

B: The tendon stitch has been inserted with the two ends emerging just proximal to the scarred tip of the tendon. With a sharp knife the tip is now cut off just beyond the point of emergence of the silk.

C: Diagram illustrating the course of the silk through the tendon.

D: The tendon suture has been inserted into the stump of the profundus and into the free tendon graft. The free ends have been pulled taut and have forced their way between the tendon fibrils, emerging near the center of the cross-cut of the tendon. The sutures have been passed about one another preparatory to knotting.

E: The tendon suture completed. The ends have been tied with slight tension so as to produce a little buckling of the tendon ends. The ends lie buried between the coapted tendons.



undercutting with the scissors until the tendon enters the carpal sheath. With a gloved finger placed around the tendon above the wrist, it is then possible with a snapping motion to pull the tendon out of the sheath. The free end is then threaded with the typical tendon suture as already described, and the tendon is divided at its musculotendinous junction. The ends of the suture are left sufficiently long so that they can be looped through the guide suture and the tendon can be pulled down through the reconstructed digital sheath. The graft itself should be somewhat longer than the distance between the stumps of the flexor profundus tendon. The operator must next determine accurately the length of the transplanted tendon. This is one of the most difficult parts of the operation, since too long a tendon will fail to give adequate flexion and too short a tendon will produce a contracture, usually of the terminal phalanx of the finger. The following method gives the best results: The wrist and finger are held at 180 degrees, and the proximal stump of the flexor profundus tendon is pulled on by means of the stitch already inserted until the

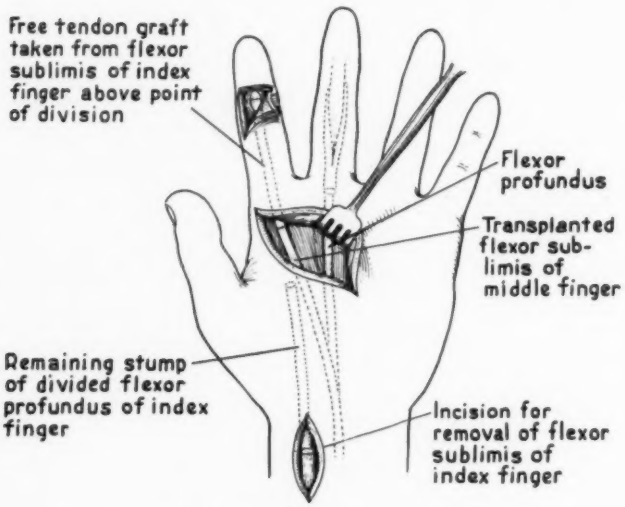

Free tendon graft taken from flexor sublimis of index finger above point of division
Flexor profundus
Transplanted flexor sublimis of middle finger
Remaining stump of divided flexor profundus of index finger
Incision for removal of flexor sublimis of index finger

FIG. 6

Transplantation of the flexor sublimis of middle finger, lengthened by a free tendon graft taken from the flexor sublimis of the index finger to replace the divided flexor tendons of the index finger. The transplanted tendons run through the sheath enveloping the celloidin tube.

limit of extension of the muscle has been reached. With a probe, the distance is now measured between the proximal and distal stumps of the flexor profundus tendon. This gives the accurate measure of the length of the graft. Its unthreaded end is then cut, in order to shorten it sufficiently; a No. 2 Deknatel silk suture is inserted at this end; and the sutures are then tied to the corresponding sutures of the profundus tendon, so as to splice the transplant between its two stumps. In tying the sutures, enough tension should be put on the silk to cause the tendon ends to buckle slightly. This helps to give accurate approximation of the tendon fibrils to one another. The union of the tendon must be sufficiently accurate so that no raw tendon surface is visible at any point, but everywhere the operator sees the smooth, gliding surface of the tendon. The knots are buried between the opposing ends of the spliced tendons. When the stitch has been completed, the finger ought to bend slightly as it is released by the operator. The operator should with ease be able to straighten the finger completely without inducing any separation at the lines of the tendon suture. The operation is completed by interrupted subcutaneous stitches and skin stitches.

If the muscles of the damaged finger tendons do not appear capable of regeneration, it is wiser to utilize the sublimis muscle of the adjacent finger as the activating power. The tendon of the adjacent sublimis is exposed near the metacarpophalangeal joint, is divided in this region, is threaded with the silk suture, and is then prolonged by means of a free tendon graft exactly as in the operation just described. (See Figure 6.)

AFTER-TREATMENT

The details of the after-treatment are no less important than those of the operation, and it is only by following them precisely that we have been able to secure gratifying end results. After the tendon transplantation, the finger is again splinted in order to avoid any undue strain on the grafted tendon. It is advisable to have the finger straight, since otherwise flexion contractures readily develop. Passive motion of the finger which has been operated upon should be begun as soon as the wound is healed, usually on the seventh or eighth day. Active exercises, combined with sinusoidal stimulation of the muscles, are begun on the ninth or tenth day. If active motion is begun sooner, there is danger of tearing the tendon ends apart. Owing to trauma and muscle disuse, the motion of the transplant is at first pitifully slight, but, as the exercises and physiotherapy are kept up, the motion increases from day to day. The physiotherapy must be continued for many weeks—in some cases several months—until function has been regained. Sinusoidal stimulation of the affected muscles is invaluable, since the patients are at first unable to contract them voluntarily. With the aid of the electric stimulus, the patients gradually learn muscle control, but only by dint of patience and persistence can the normal range of contractility be recovered.

In closing this paper, the authors feel that they ought to express a word of warning with regard to the celloidin-tube method. An impression might be gained by some that the celloidin tube exerts a magic power to transform a disabled finger into one with normal function. It is obvious that such an impression is quite erroneous. The celloidin tube is only one detail in a series of extremely complex, delicate surgical procedures. It has only one advantage,—namely, the restoration of the digital sheath which furnishes a physiological pathway for the transplanted tendon. Tendon grafting is a highly specialized surgical technique demanding of its followers not only detailed anatomical knowledge, but constant practice on the cadaver. It is only by frequent repetition that a tendon suture can be inserted with speed and minimal trauma. Unless the surgeon is willing to give adequate study and practice to tendon surgery, it is unfair to the patient, as well as to the celloidin-tube method, for him to undertake the repair of damaged finger tendons by the celloidin-tube implantation.

REFERENCES

Biesalski: Ueber Sehnenscheidenauswechslung. Deutsche med. Wchnschr., XXXVI, 1615, 1910.

Biesalski, K., und Mayer, L.: Die physiologische Sehnenverpflanzung. Berlin, Julius Springer, 1916.

Bunnell, Sterling: Repair of Tendons in the Fingers and Description of Two New Instruments. Surg. Gynec. Obstet., XXVI, 103, 1918.

Repair of Nerves and Tendons of the Hand. J. Bone and Joint Surg., X, 1, Jan. 1928.

Contractures of the Hand from Infections and Injuries. J. Bone and Joint Surg., XIV, 27, Jan. 1932.

CLEVELAND, MATHER: Restoration of the Digital Portion of a Flexor Tendon and Sheath in the Hand. J. Bone and Joint Surg., XV, 762, July 1933.

GARLOCK, J. H.: Repair of Wounds of the Flexor Tendons of the Hand. Ann. Surg., LXXXIII, 111, 1926.

HENZE, C. W., AND MAYER, LEO: An Experimental Study of Silk-Tendon Plastics with Particular Reference to the Prevention of Post-Operative Adhesions. Surg. Gynec. Obstet., XIX, 10, 1914.

KOCH, S. L.: Four Splints of Value in the Treatment of Disabilities of the Hand. Surg. Gynec. Obstet. XLVIII, 416, 1929.

The Immediate Treatment of Injuries of the Hand. Surg. Gynec. Obstet., LII, 594, 1931.

KOCH, S. L., AND MASON, M. L.: Division of the Nerves and Tendons of the Hand. With a Discussion of the Surgical Treatment and Its Results. Surg. Gynec. Obstet., LVI, 1, 1933.

MAYER, LEO: The Physiological Method of Tendon Transplantation. Surg. Gynec. Obstet. XXII, 182, 298, 472; 1916.

The Application of the Physiological Principle to Tendon Transplantations. Am. J. Surg., XXXII, 1, 1918.

Recent Studies in the Physiology of Tendons and Their Application to the Operative Treatment of Poliomyelitis. Med. Record, XCV, 428, 1919.

The Physiological Method of Tendon Transplantation. Surg. Gynec. Obstet., XXXIII, 528, 1921.

The Free Transplantation of Tendons. Am. J. Surg., XXXV, 271, 1921.

Tendon Transplantations for Division of the Extensor Tendon of the Fingers. J. Bone and Joint Surg., VIII, 383, Apr. 1926.

Surgery of Tendons. *In* The Cyclopedia of Medicine. Edited by G. A. Piersol. Philadelphia, F. A. Davis Co., 1935. (Includes complete bibliography.)

MAYER, LEO, AND RANSOHOFF, N. S.: Contribution to the Physiological Method of Repair of Damaged Finger Tendons. Preliminary Report on Reconstruction of the Destroyed Tendon Sheath. Am. J. Surg., XXXI, 56, 1936.

PRIME, FREDERICK, JR.: The Possibilities of Preserving the Integrity of Potential Body Cavities by the Use of a Foreign Body to Prevent Adhesions. Surg. Gynec. Obstet., XVII, 617, 1913.

ROENTGEN-RAY THERAPY OF BONE TUMORS *

BY HENRY W. MEYERDING, M.D., ROCHESTER, MINNESOTA

Section on Orthopaedic Surgery, The Mayo Clinic

Roentgen's discovery of the roentgen rays, in 1895, created a new field of research and stimulated the scientific world to apply the peculiar properties of these rays to the advancement of medical diagnosis and treatment.

It was soon evident that there was variation in the radiosensitiveness of different types of tumors. Although all tissue has a measure of radiosensitiveness, it was found that some tumors were comparatively radioresistant or insensitive, as is true of osteogenic sarcomata, whereas others, such as endothelial myelomata, were so remarkably sensitive that diagnostic irradiation became possible.

There exists a considerable difference of opinion as to the therapeutic value of roentgen rays. This is not surprising when one remembers that only forty years have passed since the discovery of the rays. All tumors are not amenable to surgical treatment and certainly all are not radiosensitive enough to be considered susceptible of treatment by roentgen rays. Early roentgenologists gained a foothold in the field of treatment largely through their ability to demonstrate benefit from the use of the rays and cure of certain inoperable and recurring tumors, and, as the favorable results became known, roentgenologists were asked to cooperate with other physicians and surgeons. A combination of surgery and irradiation offers greater benefit than either method alone in certain cases. In other cases, especially those of benign tumor, there is no question that surgery cures quickly and surely, in minimal time, and permits microscopic study of tissue with consequent verification of the clinical, roentgenographic, and surgical diagnosis. The claim that cure has resulted from irradiation, without microscopic proof thereof, is not always tenable. Members of the medical profession look to the teamwork of the family physician, surgeon, roentgenologist, and pathologist to bring about advances in knowledge whereby earlier diagnosis, efficient treatment, and an increased number of cures may be expected. To this end the rôle of the family physician is probably most important, for, if the patient is treated for rheumatism or sprain until the tumor has become obvious, valuable time will be lost and treatment, no matter of what type, will be of lessened effectiveness.

CASE 1. The patient was a housewife, aged twenty-six years. When three months pregnant, she had become conscious of a pain in the left groin, which was aggravated by exercise. Two and a half months later she had noticed a swelling. She had consulted

* Read before the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 13, 1936.

her family physician, who advised an immediate visit to the Clinic. Six weeks thereafter she registered at the Clinic; at that time gestation had progressed for seven months.

Examination disclosed a large mass in the left groin, which had bulged into the pelvis and which, it was evident, would render practically impossible delivery of a baby at full

FIG. 1-A

Case 1. Before roentgen-ray therapy. Destruction of left pubic bone from probable endothelial myeloma. A seven-months' foetus is in the uterus.

FIG. 1-B

Case 1. Thirteen months after roentgen-ray therapy. Following destruction of the tumor and deposition of bone, the left pubic bone has reformed.

term (Fig. 1-A). Following consultation of a surgeon, roentgenologist, and obstetrician, roentgen-ray treatment was begun the day after the patient's admission. The first course extended over five consecutive days, following which the patient went home with advice to return in one month.

The woman was next seen six weeks later, at which time she said that she had gained eight pounds (three and six-tenths kilograms), slept well, and had a good appetite. The pain was gone and the tumor was appreciably smaller. Three other courses of treatment were given in June, August, and December. The patient gained twenty pounds (nine kilograms) and felt "fine". The tumor regressed clinically and roentgenographically. After the second treatment the patient returned to her home, several hundred miles away, and was delivered of a baby, who died after one week of life. The cause of death was not known.

This case illustrates the value of roentgen-ray treatment (Fig. 1-B). The author believes that no other form of treatment would have been of use in this case; certainly surgery was out of the question. The response to irradiation makes it appear that the tumor was an endothelial myeloma. These tumors tend to metastasize, but, after eighteen months, roentgenograms of the thorax and the clinical examination gave negative results. The patient had had no other treatment.

PREOPERATIVE IRRADIATION OF BONE TUMORS

Preoperative application of irradiation recently has been discussed considerably and the method has gained acceptance in some medical centers. Its field of usefulness, the writer believes, is very limited and its indiscriminate use may be more harmful than beneficial. What is needed is early diagnosis, destruction or removal of the tumor, and prevention of metastasis by whatever means may be available. Effective preoperative irradiation, since it consumes valuable time, may permit metastasis of malignant tumors to occur, and in treatment of benign tumors there is seldom need for such a procedure. On the other hand, a tumor may be so situated and of such a size as to make surgical removal impossible, whereas the growth may diminish in size following irradiation and thus become operable. From the author's observations he cannot see the value of irradiation preceding biopsy, or the value of routinely treating malignant tumors before amputation or

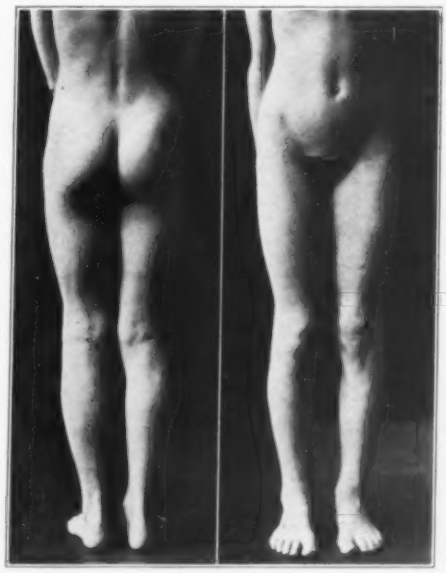


FIG. 2

Case 2. Posterior and anterior views, showing slight enlargement of the left thigh from probable endothelial myeloma of the left femur. The symptoms had been present only one month.

FIG. 3-A

Case 2. Before roentgen-ray therapy, January 1929.

FIG. 3-B

Case 2. After roentgen-ray therapy, August 1929.

FIG. 3-C

Case 2. Roentgenogram, August 1934. The lesion was probably an endothelial myeloma.

excision. Although such treatment may give the roentgenologist an idea as to the radiosensitiveness of the tumor, temporary improvement gives the patient a sense of false security; thus, exploratory operation may be postponed, and the advantages of early and accurate diagnosis, immediate surgical treatment, and examination of tissue by a pathologist may be deferred or lost.

CASE 2. (Registry of Bone Sarcoma, No. 1756.) A girl, aged thirteen years, was brought to the Clinic in January 1929. A month previously she had noticed a swelling and had experienced throbbing pain in the upper portion of the left thigh (Fig. 2). These symptoms had disappeared in a week, but about a week before she came to the Clinic the symptoms had reappeared and the pain and throbbing had been worse at night than during the day.

On examination a firm, fixed mass and enlarged veins were found in the lateral aspect of the left thigh. The temperature, the urine, and the leukocyte and erythrocyte counts were normal. The Wassermann reaction of the blood was negative and roentgenographic examination of the thorax gave negative results.

The roentgenographic diagnosis relative to the thigh was periosteal sarcoma. The surgeon's preoperative diagnosis was tumor of indefinite nature. The surgeon also gave the opinion that the growth was too high for successful amputation and he advised biopsy, irradiation, and administration of Coley's toxin. Biopsy was performed, and the diagnosis made from microscopic examination of the tissue was Ewing's tumor.

Three courses of irradiation were given in January, February, and May. Furthermore, Coley's toxins were administered by the patient's home physician in February and May 1929, and administration of these toxins was continued thereafter for six months; injections were made once a week.

In August 1935 a report was received that the girl's general health was good and that she had no trouble with the left leg. She was alive and well over five and a half years following biopsy, irradiation, and toxins.

POSTOPERATIVE IRRADIATION

This method of treatment has been employed following biopsy, excision, curettage, and amputation in the hope that remaining cells may be destroyed, that metastasis may be prevented, or that unrecognizable metastasis may be adequately dealt with. For this reason, the common sites of metastasis and the territory occupied by the lymphatic structures which drain the region of the tumor are irradiated; if the malignant cell present is of a radiosensitive type, there is some hope that the remaining elements will be destroyed. The beneficial effects from this form of treatment partly result from the action of the rays on the blood vessels and the formation of connective tissue; the malignant cells which remain become enclosed in masses of fibrous tissue, of which the blood supply is impaired and growth is thus inhibited. Late recurrence may be explained in this manner in some cases, but the author has seen malignant cells at the site of previous operation and extensive irradiation, when clinical manifestations of tumor were not present. Postoperative irradiation may be one of the reasons why more five-year cures are recorded now than formerly, but the writer thinks an equally important reason is that diagnosis is made earlier than formerly and, therefore, efficient treatment is carried out.

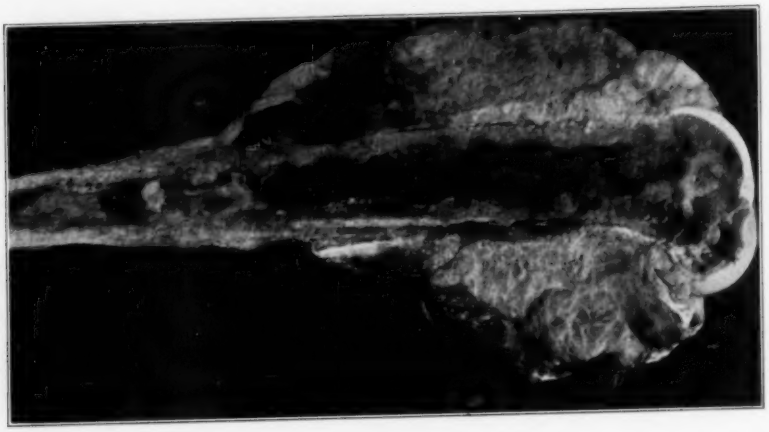


FIG. 4-C

Case 3. Gross sagittal section of the tumor.

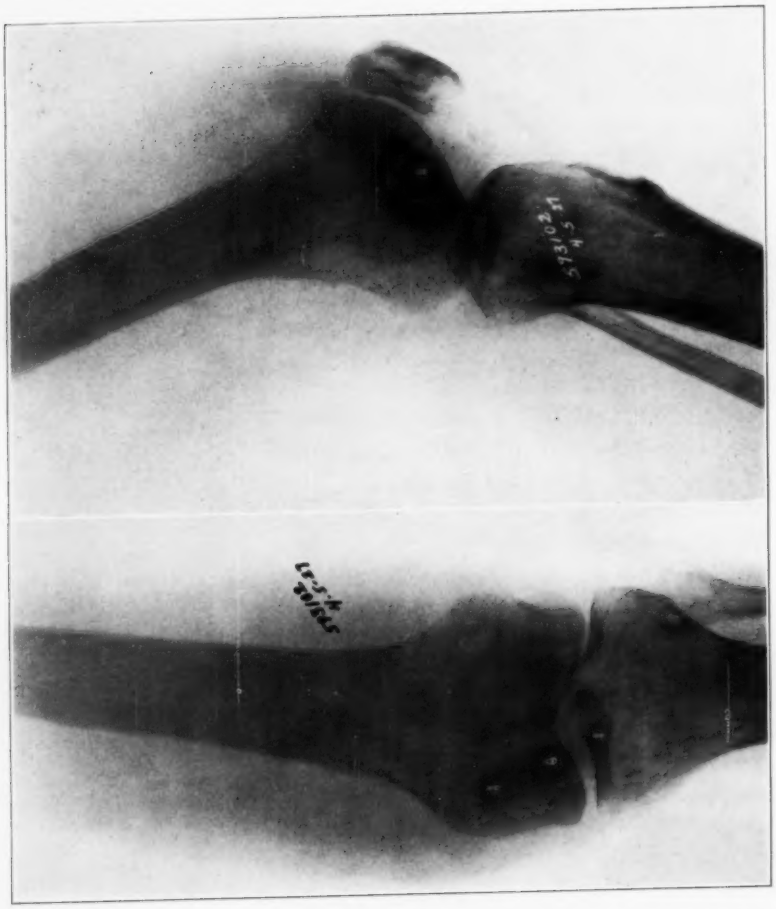


FIG. 4-A FIG. 4-B

Case 3. Anteroposterior and lateral roentgenograms, showing appearance of the tumor.

CASE 3. In April 1927, the author saw an engineer who complained of having had pain about the left knee for a year and swelling of the lower end of the left femur for four months. He said that his mother's left leg had been amputated for sarcoma.

On examination, the circumference of the left leg was four and one-half inches (eleven and five-tenths centimeters) greater than that of the right leg, and reduction in motion of the left knee limited movement of the leg to the arc between 90 and 160 degrees. The superficial veins were enlarged and there was some local increase in temperature. Roentgenographic examination gave evidence of a soft-tissue tumor (Figs. 4-A and 4-B) and periostitis, involving the lower part of the femur; roentgenograms of the thorax gave negative results.

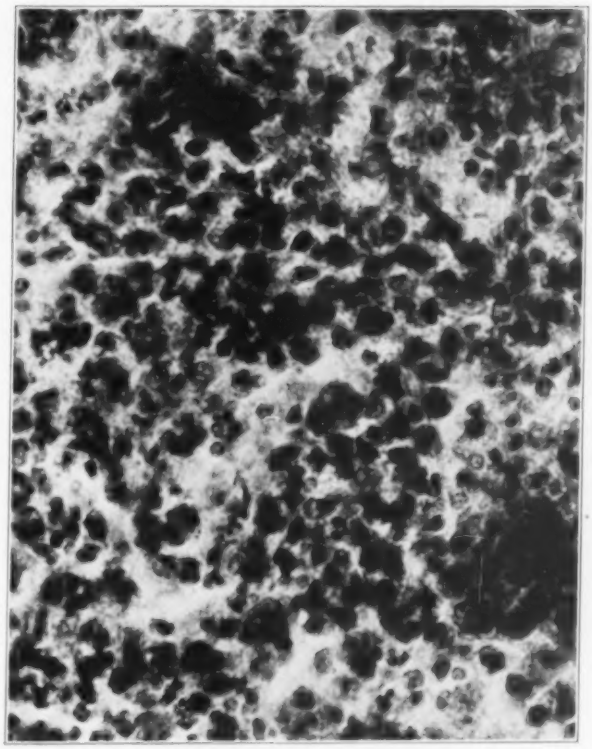


FIG. 5

Case 3. Microscopic appearance of tumor diagnosed by different pathologists as "highly malignant, cellular, round-cell sarcoma" and "endothelial myeloma".

The surgeon advised that a section of tissue be removed for confirmation of a diagnosis of sarcoma, this to be done with tourniquet applied, and, if the pathologist should find evidence of malignancy in a frozen section, that amputation be performed immediately. At operation the tissue was reported to be that of a highly malignant sarcoma, and amputation was performed through the upper part of the femur (Fig. 4-C).

The patient made an uneventful recovery, was given a course of roentgen-ray treatments, and was dismissed one month from the time of his admission. Five years later he reported: "I have taken on weight and am of robust appearance, a physical specimen you would be proud of." In a still later report, his physician stated that the patient was living and well more than eight years after treatment.

This patient was given every care—examination, consultations of surgeon, roentgenologist, and pathologist, operation and postoperative irradiation—and was returned home with his wound healed in one month. He came 2,300 miles, but he saved valuable time thereby; it was not necessary to send roentgenograms or tissue to experts at various distances and to subject him to preliminary irradiation while waiting for their replies. The microscopic slide (Fig. 5) has been examined recently by pathologists. One reported "highly malignant, cellular, round-cell sarcoma"; another, "endothelial myeloma".

SOME FACTORS IN THE REACTION OF TUMORS TO IRRADIATION

The response to irradiation usually will be determined by what cell is predominant. Thus, a certain type of tumor may vary in the degree with which it reacts; it may be wholly or only partially destroyed. There is a difference between the radiosensitiveness of tissues and cells of normal structures on the one hand and the radiosensitiveness of tumors on the other hand. Thus, a mixed-cell tumor may have a great proportion of radiosensitive cells and for a time may retrogress rapidly. After these radiosensitive cells have been destroyed, the remaining, more resistant cells continue to grow and are not affected by continued irradiation. Knowledge is accumulating as to the methods of application of irradiation to tumors of various situations and various cellular classifications; at present, repeated courses of protracted fractional irradiation, with cross-firing, appears to be the most satisfactory method. Roentgenograms should be made from time to time in order to visualize the effects of irradiation. As one becomes acquainted with the course of bone tumors, one learns not to be alarmed by temporary increase in swelling, pain, or redness, or by local increase in temperature and by what may appear, in the roentgenograms, to be evidence of increase in absorption of bone, such as is seen in certain cases of giant-cell tumor.

FIG. 6

Case 4. Secondary sarcoma of the left ilium, on the basis of an old osteochondroma.

BENIGN OSTEOGENIC TUMORS

These tumors commonly are known as exostoses, osteochondromata, chondromata, and fibromata. They are relatively insensitive to irradiation. Because they are readily cured by surgical operation, treatment by roentgen rays has received little attention. If there is doubt as to the malignant transformation of a tumor of this group, the author favors excision and postoperative irradiation; the tumor must be entirely re-

moved, especially if it is a chondroma, and, if doubt exists as to its having been completely eradicated, the actual cautery is employed.

CASE 4. In May 1925, a farmer, aged thirty-nine years, was referred to the Clinic by his family physician, because of a tumor of the left hip. Eight years before, the patient's pelvis had been crushed in an accident. A year later he had begun to have pain in the left buttock, and eighteen months after the accident a mass was discovered in the upper part of the left femur. The tumor was not tender and annoyed him only on motion. It enlarged slowly and after five years of growth a surgeon had removed it. The patient was told that it was a sarcoma. It recurred in three weeks and the patient was given a series of twelve roentgen-ray treatments; however, the mass continued to enlarge at about the same rate as before.

On examination (Fig. 6), a huge, fixed, hard tumor was found, extending about the ilium; the scar of the previous operation was evident. Three surgeons were of the opinion that the tumor was a chondroma, undergoing malignant change, and advised excision followed by irradiation. Urinalysis and examination of the blood, including the Wassermann reaction, gave negative results. The patient looked well and was of good weight.

At operation a huge osteochondroma, weighing three and one-half pounds (one and six-tenths kilograms), was excised from the ilium. The tumor extended from the femoral trochanter up into the abdomen to the spine, and had pushed the femoral artery inward. A poor prognosis was given by the surgeon. The pathologist made a diagnosis of osteochondroma. A course of three roentgen-ray treatments was given and the man was referred to his local roentgenologist for continuance of the irradiation.

Eighteen months later the patient wrote that recurrence had taken place. Twenty-seven months after the author had operated the patient's physician wrote that he had operated in order to drain a large amount of serosanguineous material and pus, because the patient was toxaemic and had a high fever. A month later the patient died of "malignant disintegration of the tumor", more than ten years after the tumor had first been noted.

BENIGN GIANT-CELL TUMORS

There has been considerable difference of opinion as to the relative merits of surgical operation and irradiation for the treatment of this group of bone tumors. Certainly all are not susceptible of surgical treatment, in view of their situation, their size, and the danger of hemorrhage and infection. For this type of giant-cell tumor, irradiation is advisable. In these cases, considerable judgment is required in order to determine the most advantageous form of treatment and the author cannot agree with some who believe that radiotherapy has solved the problem. Most of these tumors, excluding those of the jaws, occur in the lower end of the femur, the upper end of the tibia, or the lower end of the radius. They are usually discovered while yet of such size as to permit of surgical removal with minimal expense and loss of time. It is well to remember that the roentgenographic characteristics of benign giant-cell tumors do not always determine absolutely the absence of malignancy, whereas, if operation is performed, the opportunity is afforded to have a microscopic diagnosis made from frozen sections of tissue while the surgeon is at work. Prolonged irradiation of young individuals may lead to regression of tumors and to deposition of bone after a period of months or years, but at the expense of considerable money and of possible extensive damage to uninvolved tissue. The experienced surgeon may accomplish a cure in a

FIG. 7

Case 5. There is evidence of absorption of bone on the mesial side of the femur, including both the diaphysis and the epiphysis. The tumor bulges into the soft tissues. The outline of the tumor is not clear and lines or striations cannot be seen in the mass.

few weeks and be sure of what type of tumor he has to treat, in most cases. The writer realizes that the older accounts indicate that amputation was performed in a high percentage of cases, that infections were common, and also that control of hemorrhage was difficult. All of this makes it appear that operation was attended by undue surgical risk, but surgeons have perfected their technique and, in the author's opinion, surgical operation maintains first place as a means of treating this tumor.

CASE 5. A woman, aged twenty-two years, came for consultation in October 1917, complaining of having had pain, swelling, and stiffness of the left knee for five months. She had been told that she had a sarcoma and "injection treatment had been given". The tumor had increased in size, disability had increased, and amputation had been advised. She came to the Clinic seeking to avoid amputation.

On examination, the roentgenologist believed that a sarcoma was present (Fig. 7). Nevertheless, the surgeon advised exploration and microscopic examination of tissue; this was accepted by the patient and the growth was found to be a benign, giant-cell tumor. The tumor occupied the mesial side of the lower epiphysis and part of the shaft of the femur, and it contained reddish, jamlike tissue. The cavity was curetted until every vestige of tumor had been removed; then the cavity was cauterized with the actual cautery and packed with gauze; and fifty milligrams of radium was left in the cavity for twenty-four hours. Three weeks later another radium treatment was given, making a total of 1,750 milligram hours. The patient was dismissed on the twenty-sixth day after operation and returned home.

Eighteen years later she reported that she was married and well.

This case illustrates the value of biopsy and the opinion of a competent pathologist before advising amputation. This case was encountered a number of years ago and the rapid growth and roentgenographic appearance led to the diagnosis of malignancy. Although irradiation might

have relieved the condition, the time required would have been long. By means of the combined treatment, the patient was relieved of her anxiety, became cured, and in twenty-six days returned to her home, which was 1,500 miles away.

Ordinarily, complete removal of these benign growths will effect cure. Some reach such size as to make operation hazardous. Joints may be involved, but they seldom are. Rarely are these tumors of such size as to require amputation, but extensive involvement, injury to joints, infection, or excessive irradiation may so damage the tissue as to produce a useless limb. Irradiation is preferred for tumors that are inaccessible to surgical removal, as are those of the spinal column and bony pelvis.

HEMANGIOMA

Hemangioma affecting bone is moderately radiosensitive and under moderate dosage, repeated at regular intervals for a number of months, gradually regresses until healed.

HEMANGIO-ENDOTHELIOMA

Hemangio-endothelioma is less radiosensitive than endothelioma or hemangioma and tends to improve temporarily under irradiation.

ENDOTHELIAL MYELOMA

Endothelial myeloma is the most radiosensitive of bone tumors, and complete regression of the local growth may be observed under irradiation competently applied. So uniform is the response to irradiation that diagnostic irradiation has been advocated and is considered sometimes to prove more reliable than the opinion of the average pathologist. While

FIG. 8-A FIG. 8-B

Case 6. Osteogenic (Ewing's) tumor of the right shoulder.
Fig. 8-A: Appearance of patient on admission.
Fig. 8-B: After irradiation.

the tumor and symptoms may disappear under treatment and the bone may assume normal appearance, the treatment often fails to effect cure because of metastasis. Early radiotherapy, before metastasis has occurred, may result in permanent cure. Opinion as to the merits of treatment recently appears to favor amputation, irradiation, and administration of Coley's toxins.

CASE 6. In July 1930 a farmer, forty-eight years of age, arrived at the Clinic, complaining of pain in the right shoulder. He said that four years before, while cranking an automobile, a back-fire of the motor had injured his right shoulder. The pain of the injury had persisted and three months after the accident he had noticed swelling over the right scapula. This swelling had continued to enlarge. About three years before he came to the Clinic the tumor had been excised and a diagnosis of sarcoma had been made. In the next three years, excision was performed twice, but the tumor had recurred.

FIG. 9

Case 7. Destruction of the ulna caused by osteogenic sarcoma with infection.

On examination, the man was found to be of normal weight. A large tumor, with scars of the previous operation, was found over the right scapula (Fig. 8-A). The tumor was fixed, of generally rubberlike consistency, and contained softened portions. Urinalysis and examinations of the blood gave negative results. The roentgenogram of the thorax was negative. The diagnosis, both of roentgenologists and of surgeons, was osteogenic sarcoma. Extensive amputation was considered, but was abandoned in favor of irradiation. Examinations of the tissue obtained by the home physician resulted in a diagnosis of Ewing's tumor.

Courses of irradiation were given in July, October, and December. The patient made marked general improvement and gained weight (Fig. 8-B). The tumor decreased rapidly in size.

In March 1932 a large metastatic growth appeared in the right ilium and skull, and courses of irradiation were given. By July 1933, the tumor of the skull had disappeared and that in the ilium had greatly diminished in size. At that time another course of irradiation was given. In February 1934 the home physician irradiated the left shoulder and reported that there was metastasis in the lungs. The patient died from metastasis in July 1934. This was about eight years from the time of discovery of the tumor.

OSTEOGENIC SARCOMA

Osteogenic sarcomata, as a group, are highly resistant to irradiation and, although some regression of symptoms may follow such treatment, its principal

value in the author's opinion is that it gives relief of pain in conjunction with surgery. Studies in the larger clinics and data assembled by the Registry of Bone Sarcoma do not hold out much hope of permanent benefit from irradiation; excision and amputation appear to be most beneficial. As some patients will not consent to operation, irradiation may be chosen. The writer is not impressed by the use of irradiation as a preliminary form of treatment and believes early diagnosis, radical surgical operation, postoperative roentgen-ray therapy, and administration of toxins have given the most encouraging results.

CASE 7. A girl, aged seventeen years, came to the Clinic in May 1931, because of pain in the arm, following a sprain of the left wrist eighteen months before. Recovery from the sprain had been slow, but the patient had been able to play basketball. About a year before she came to the Clinic the left arm had swollen somewhat, but there had been no soreness or fever. About that time, a roentgenogram had been made and a diagnosis of greenstick fracture had been given. Splints had been applied and left in place for three weeks, but the pain had continued and the splints had been removed. They had been replaced, however, and the patient was wearing them when she arrived at the Clinic. She said that a diagnosis of osteomyelitis had been made, and that an area of redness had been incised six weeks before the writer saw her. She had lost ten pounds (four and five-tenths kilograms) in three weeks, and her appetite was poor. An interesting feature of the history was that a sister had undergone amputation of a leg for sarcoma.

On examination, the lower third of the left arm was swollen and red, and pus was draining from the wound of the previous excision. Flexion contracture of the fingers and wrist was present. The temperature was 101 degrees Fahrenheit and the pulse rate was 120 per minute.

Physicians, surgeons, and roentgenologists made a diagnosis of malignant sarcoma of the left ulna (Fig. 9). Amputation was advised, but the patient refused to submit to it. Biopsy was performed, however, and the pathologist reported osteogenic sarcoma, grade 4.

In May, June, and July courses of irradiation were given under the following conditions: 135 kilovolts, 5 milliamperes, 6 millimeters of aluminum filtration. Ulceration and sequestration occurred and the arm appeared shrunken as compared with the condition before biopsy and irradiation. The patient gained four pounds (one and eight-tenths kilograms) in four months. Six months after the biopsy, a sequestrum was removed from the mass in the forearm. The patient's family doctor wrote that she died a "pulmonary death" seventeen months after biopsy.

MULTIPLE MYELOMA

Multiple myeloma presents a hopeless surgical problem, and irradiation gives only mildly encouraging results. Relief of local symptoms when the disease is recognized early, and some retardation of growth, with considerable improvement for a period of about one to two years, is about all that there is to look forward to. The disease is fatal in spite of any known treatment.

METASTATIC CARCINOMA

In cases of metastasis from carcinoma of the breast, thyroid gland, uterus, stomach, and prostate gland, a measure of relief from pain may be given and rapidity of growth may be delayed by roentgen-ray therapy, but the generalized process goes on and the benefits frequently are of ques-

tionable value. These metastatic growths often are considered as primary bone tumors and their true nature remains undiscovered until late in the disease or until necropsy is performed. Nevertheless, the author believes that the prolongation of life and relief of pain obtained through roentgen-ray therapy would cause anyone afflicted to choose this method of treatment.

COMMENT AND SUMMARY

It is obvious from experience extending over a period of years, that roentgen-ray treatment of bone tumors is not a cure-all. On the other hand, it has an important field of usefulness. The possibilities of irradiation have not been exhausted and time will bring about greater improvement in its application and increase its therapeutic value. Surgeons and roentgenologists must go on cooperating to improve results; when the family physician is able to make the diagnosis earlier, and if he will then refer patients to centers where every aid is available, progress through further research will follow.

DIFFICULTIES IN THE DIAGNOSIS OF BONE TUMORS*

BY R. I. HARRIS, M.B., F.R.C.S. (C), TORONTO, CANADA

Associate Surgeon, Toronto General Hospital

Even a brief experience with bone tumors reveals the difficulties which surround diagnosis,—the history of the case may not be distinctive; the physical examination may reveal little; and the roentgenographic examination, though of the utmost value and the most important single means of examination, may be misleading. It is the purpose of this paper to discuss certain problems in diagnosis which the author has encountered.

There are available four sources of information from which facts may be obtained for the purpose of reaching an accurate diagnosis,—namely, history, physical examination, roentgenographic examination, and biopsy. From each, valuable information can be obtained, but each also has its limitations.

Too much emphasis cannot be laid upon the importance of a carefully taken history in which especial attention is paid to those features which concern lesions, such as syphilis and osteomyelitis, which are often confused with bone tumors. Yet, at its best, the history rarely yields sufficient information to permit a more accurate diagnosis than malignancy, leaving the determination of the type of bone tumor to other methods.

The importance of the history is revealed by the following case.

CASE 1. W. F., a male, aged twenty-eight years, first experienced pain in the right thumb in May 1935. In July 1935, swelling along the metacarpal was first noticed. The swelling increased rather rapidly and then remained stationary. Pain, at first not severe, slowly increased in intensity until the patient was compelled to give up his work as a carpenter.

His general health had been good save for acute appendicitis ten years previously. Some time after appendectomy, the scar had bulged. Operation, undertaken for the repair of ventral hernia, had revealed tuberculous peritonitis. The patient had been obliged to remain in bed eleven months from June 1925 to May 1926. In 1928 he had had an attack of gonorrhoea.

Examination in October 1935 revealed an enlargement of the whole of the metacarpal of the thumb. It was twice its normal size. Tenderness was rather marked. Movement was limited and moderately painful at the carpometacarpal and metacarpophalangeal joints. The Wassermann reaction was positive, four plus.

Roentgenographic examination (Fig. 1) showed extensive involvement of the whole of the metacarpal bone. Its original outline was almost entirely lost in a pathological process which had produced multiple small areas of destruction, superimposed upon which was a great amount of new bone laid down irregularly beneath the periosteum. There were no radiating spicules and no uniform layers of subperiosteal bone.

As diagnosis was uncertain, a biopsy was performed. This revealed a tuberculous inflammatory reaction.

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 13, 1936.

The diagnosis in this case was difficult and uncertain. Physical and roentgenographic examinations suggested bone tumor or low-grade osteomyelitis. For bone tumor, the roentgenogram suggested Ewing's endothelioma, because of the multiple small areas of bone destruction and the irregular masses of new bone. Against such a diagnosis was the age of the patient, the bone involved, and the absence of roentgenographic changes indisputably characteristic of Ewing's endothelioma. Against osteomyelitis (pyogenic, tuberculous, or syphilitic) was the absence of marked evidences of inflammation or of pus. The critical feature lay in the history of earlier tuberculosis.

Physical examination in characteristic cases can yield facts of the utmost importance, upon which an accurate diagnosis of tumor and of the type of tumor can often be made. The age of the patient, the bone involved, the situation of the tumor in the involved bone, and the characteristics of the tumor itself are factors which, when taken together, may constitute a clear-cut clinical picture. Real difficulties arise when the tumor occurs in an unusual situation. Here many of the distinctive features are lost and the history, as well as the clinical examination, does little more than suggest a malignant lesion. These remarks refer, of course, to the

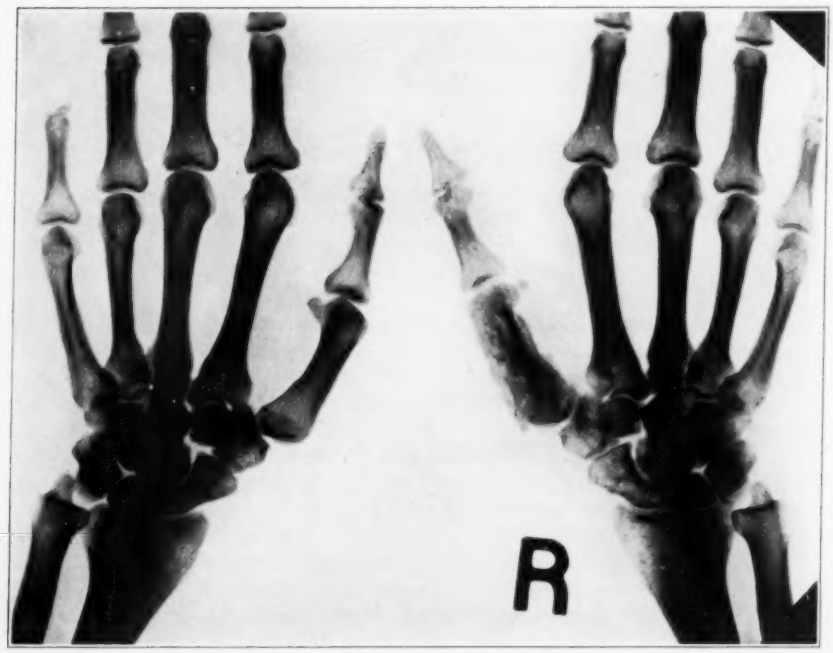


FIG. 1

Case 1. Roentgenographic appearance of destructive and productive lesion of the metacarpal bone of the right thumb, somewhat resembling Ewing's tumor. Biopsy proved the lesion to be tuberculous. This case illustrates the value of the case history in diagnosis of a bone tumor; this patient had previously suffered from tuberculosis.

early diagnosis of bone tumors. In their later stages their nature is only too obvious.

Good roentgenograms are of the utmost value in reaching a diagnosis of bone tumor and in establishing its exact nature. The progress made in the knowledge of bone tumors would not have been possible without the aid of the roentgenogram. It is the most important single agent for diagnosis at our disposal. Careful and critical analysis will yield much information.

Even the roentgenogram has its limitations. What it can reveal with absolute fidelity are the changes produced in a bone by the presence in it of a malignant tumor. There is nothing in the roentgenogram which is pathognomonic of the particular tumor cell which is causing the changes in its host. Certain tumors commonly give rise to changes which recur with sufficient frequency to lead us to feel that such changes are distinctive, but this evidence is not quite trustworthy. Exceptions occur which make it impossible to say that such and such a roentgenographic appearance always means such and such a bone tumor. The value of the roentgenogram lies in the perfect fidelity with which it reproduces bone changes, including the formation of such new bone as may come from the tumor. Careful observation and sound deduction add much to the knowledge obtainable from the roentgenogram.

We naturally rely greatly upon the roentgenogram as the most important agent in reaching a diagnosis. So revealing is it of changes in bone that often we place too much reliance upon it. The following cases indicate this difficulty:

Case 2. I. S., a female, fourteen years of age, while standing on her head in July 1933, experienced a pain in her neck. It continued for four or five days and was accompanied by stiffness. Ultimately it disappeared. A month later she tripped on a stump and fell. When she got up, she walked with difficulty, but she managed to get home. The next morning her legs were completely paralyzed, and two days later her arms also became paralyzed and she became incontinent. The history was otherwise irrelevant.

Examination showed complete paralysis and anaesthesia below the level of the fourth cervical segment except for feeble movement in the left fingers. There was incontinence of urine and faeces. A roentgenogram (Fig. 2) showed a destructive lesion of the fifth cervical vertebral body with marked collapse.

It happened that shortly before this, the author had seen a male, aged thirty-five, with a similar lesion. As he was cranking his car, the crank handle slipped from the shaft and his effort straightened out his trunk with a snap. There was immediate pain in the neck and a roentgenogram (Fig. 3) revealed a pathological compression fracture of the body of the fourth cervical vertebra. Symptoms of cord pressure were mild. A clinical and roentgenographic diagnosis of giant-cell tumor was made. Treatment by fixation and x-ray resulted in marked improvement so that the patient was able to leave the hospital. On the first day that he returned to work he had the misfortune to be thrown from his milk wagon to the pavement, sustaining a fractured skull from which he died. A post-mortem examination was made and the cervical spine was removed. This revealed a giant-cell tumor.

With such a case as a recent memory, it was not unnatural that the author should regard this child's lesion as a giant-cell tumor also. Paraplegia was so complete that laminectomy was performed on August 4, 1933. This operation revealed replacement of

FIG. 2

Case 2. A destructive lesion of the body of the fifth cervical vertebra with collapse and paraplegia. Its course and the roentgenographic appearance so closely resembled a proved case of giant-cell tumor (Fig. 3) that this diagnosis was held to be correct until biopsy proved the lesion to be Ewing's tumor.

FIG. 3

A proved case of giant-cell tumor of the third cervical vertebra. The history, physical findings, and x-ray appearance so closely resembled those of Case 2 (Fig. 2) that accurate distinction was possible only by biopsy.

the spinous process and lamina of the fifth cervical vertebra by a tumor. Frozen section ruled out giant-cell tumor and suggested myeloma, but paraffin section proved the tumor to be Ewing's endothelioma. This diagnosis was confirmed by the Registry of Bone Sarcoma (Case No. 1590). No improvement followed operation. The patient died eleven months later. There was great extension of the tumor locally and another similar tumor was apparent over the sacrum.

In this case the diagnosis could not be made except from section. The history and the physical examination indicated transverse-compression myelitis of the cervical cord. The roentgenogram so closely resembled a proved case of giant-cell tumor that this was the diagnosis which was made. Biopsy proved the tumor to be Ewing's endothelioma.

CASE 3. A. W., a female, aged twenty-one years, in January 1935 commenced to experience pain in the right hip without any preceding trauma. The pain slowly increased and kept her awake at night. Jarring increased the pain. On admission in July 1935, she walked with a marked limp and presented limitation of movement of the hip joint to one-half the normal range. Muscle spasm was present as well as tenderness over the hip joint on pressure. There was atrophy of the thigh amounting to one inch.

A roentgenogram (Fig. 4) showed a destructive lesion of the neck of the femur without expansion of the cortex and without clearly defined outlines. A diagnosis of osteogenic sarcoma was made.

Biopsy, on July 13, 1935, revealed the typical gross and microscopic appearances of a giant-cell tumor. The tumor was cleanly removed by curettage, and the wound was closed tightly.

In this case the history and physical examination indicated only some lesion of uncertain nature in the hip joint. The roentgenogram showed the picture characteristic of osteolytic osteogenic sarcoma. Biopsy was the only measure which revealed the true nature of the tumor.

FIG. 4

Case 3. A giant-cell tumor of the neck of the femur which lacks the distinctive roentgenographic appearance. Accurate diagnosis was reached only by biopsy.

CASE 4. R. F., a thirteen-year-old boy, was first seen in December 1932. Three months

prior to admission, soreness and tenderness on the outer side of the left leg had attracted attention to a swelling. Under treatment with iodine, the soreness and swelling was said to have diminished and for two months the patient had not been much disabled by it. During the two weeks prior to examination there had been recurrence of soreness, redness, and swelling. There was no history suggesting osteomyelitis.

Examination showed a healthy boy who walked without a limp. The upper half of the outer side of the left leg was swollen, tender, and red. The swelling was hard, in places bony hard, and centered about the fibula. The fibula seemed slightly longer than normal, so that the leg was distorted by angulation.

FIG. 5

Case 4. A case of Ewing's tumor which presented the x-ray appearance of osteogenic sarcoma with especially well-marked sun rays. Accurate diagnosis was reached only after section following amputation.

A roentgenogram (Fig. 5) showed what seemed to be a typical osteogenic sarcoma of the upper end of the fibula. Sun-ray spicules were particularly well marked, as well as the terminal subperiosteal wedge.

The leg was amputated on December 10, 1932, and the specimen was examined. Histologically the picture was that of Ewing's endothelioma. Dr. Ewing himself stated: "The sections show a rather typical endothelioma." The majority of opinions expressed by the Registry of Bone Sarcoma (Case No. 1456) were in favor of Ewing's tumor.

The patient is still alive and well, three years following operation.

This case well illustrates how misleading a roentgenogram can be. The situation of the tumor and the position and type of the new bone formed seemed characteristic of osteogenic sarcoma. The histological section alone revealed the true nature of the tumor.

CASE 5. A. M., a male, aged twenty-one years, in August 1935, while standing at the edge of the lake preparatory to plunging in, raised his arms above his head to dive. As he did so, he experienced a sharp pain in the right shoulder. He was unable to use his arm and this disability continued until his operation in October 1935.

Eight years previously, while in a hospital for an acute mastoiditis, the patient had had some trouble with this shoulder and a roentgenogram had been taken. He was told that a cystic condition was present, but, because of the acute infection, it was felt unwise to do anything about it at that time. The acute mastoiditis was followed by suppurating glands in the neck. The course which they followed suggests they may have been tuberculous glands. Since the occasion eight years previously, when the lesion in the shoulder had been diagnosed by roentgenographic examination, from time to time the patient had experienced clicking and pain. Nevertheless he had led an active and particularly athletic life.

Examination in October 1935 showed the right arm held to the side by muscle spasm. Crepitus was present on movement. A roentgenogram (Fig. 6) showed a picture typical of benign giant-cell tumor.

On October 11, 1935, a biopsy was performed. The lesion was a cavernous space in the head of the humerus, lined with dense fibrous tissue and containing in its center yellowish, firm, custardlike material. Frozen section revealed the lesion to be tuberculous. A second frozen section yielded the same diagnosis. The material filling the space was carefully removed with a curette and the wound was packed with iodoform gauze.

Tubercle bacilli were subsequently recovered by guinea-pig inoculation and on culture.

There was nothing in the history of this patient to suggest that he had tuberculosis of the shoulder. The story of his recent disablement was typical of a pathological fracture which was indeed present in the roentgenogram. The roentgenographic appearance was typical of giant-cell tumor and most atypical of tuberculosis. Only the frozen section and the subsequent recovery of tubercle bacilli made possible an accurate diagnosis.

Experiences such as these and many others have led the author to feel that a biopsy forms an important part of the examination of a case of bone tumor. The number of cases in which clinical and roentgenographic diagnoses have been changed by histological section is considerable, amply sufficient to make one feel that biopsy should always be performed in any case of doubt.

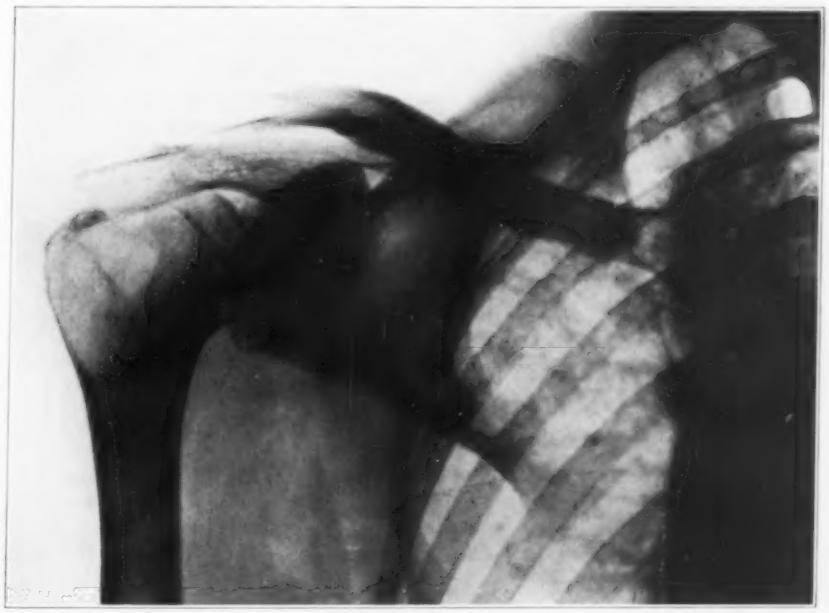


FIG. 6

Case 5. Tuberculosis of the head of the humerus presenting the roentgenographic appearance of giant-cell tumor. Biopsy revealed the true nature of the lesion and tubercle bacilli were recovered on guinea-pig inoculation.

FIG. 7

Case 6. An atypical destructive lesion of the center of the shaft of the humerus with pathological fracture. Because of its resemblance to Fig. 8, it was believed to be an atypical giant-cell tumor.

FIG. 8

In this case the lesion, the x-ray of which closely resembles Fig. 7, proved to be a giant-cell tumor with malignant propensities. Local recurrence after resection necessitated amputation.

FIG. 9

Case 6. Roentgenogram showing how the destruction of the humerus (Fig. 7) had progressed in eight months. Diagnosis made from biopsy was osteogenic sarcoma (Registry of Bone Sarcoma, Case No. 1430). No recurrence four years after amputation.

The author is well aware of the objections which may be raised against biopsy. There will be constantly advanced the possibility of disseminating the disease by cutting into the tumor. This may be true, although the writer is not convinced by the evidence which is advanced. Certainly those tumors upon which biopsy is not performed metastasize frequently and early, and, in the author's experience, as readily as do any tumors which have been examined. The great advantages of biopsy should not be discarded for an unproved fear.

A more serious objection is the difficulty which the pathologist may have in reaching a diagnosis even when he has the tissues under the microscope. This is a very real difficulty to which sufficient appreciation is not given. It can be illustrated by the following case.

CASE 6. Mrs. M. B., aged twenty years, sustained a fracture of the left humerus in March 1932. The injury was a trivial one and roentgenographic examination showed that the fracture had occurred through an area of bone destruction,—a pathological fracture. In spite of this, the fracture was treated by fixation in plaster. Three months later there was complete non-union and a roentgenogram (Fig. 7) showed absorption of two inches of the middle of the shaft of the humerus. There was evidence of expansion of the cortex of the shaft. The roentgenogram did not resemble any of the usual pictures of bone tumor.

Shortly before this, the author had seen a man with a similar destructive lesion in the middle of the shaft of the humerus. The roentgenogram (Fig. 8) presented many of the features characteristic of giant-cell tumor—expansion of cortex, clearly defined outline, and trabeculation—but the situation was unusual. Biopsy revealed the typical histology of a giant-cell tumor. Local resection with reconstruction of the humerus was performed. A recurrence in soft tissues, which did not respond to x-ray treatment, necessitated amputation of his arm.

Such an experience led the writer to feel that he was dealing again with an atypical giant-cell tumor. Biopsy was performed on May 30, 1932. The tissue was reported upon by Dr. W. L. Robinson as osteogenic sarcoma. In the gross, the tumor proved cystic; the walls consisted of yellow tissue. Dr. James Ewing saw this patient and the biopsy material. He expressed the opinion that the tumor was not essentially malignant and advised a local resection of the tumor. In the meantime there had been rapid increase in the destruction of the shaft of the humerus, as shown by the roentgenogram (Fig. 9). The fluid in the cyst accumulated rapidly and under tension. Aspiration of this fluid was undertaken to relieve the patient's discomfort. Finally, aspiration had to be performed daily.

On December 12, 1932, an attempt was made to perform a local resection of the tumor. Difficulties from hemorrhage resulted in injury to the brachial artery, which compromised the blood supply to the arm, and gangrene supervened. On December 16, 1932, the arm was removed by disarticulation at the shoulder.

The material submitted to the Registry of Bone Sarcoma (Case No. 1430) is reported upon as osteogenic sarcoma. The patient is alive and well four years after the onset of her symptoms.

Some of the pathologist's difficulties can be removed by providing him with an adequate amount of tissue to examine. For this reason the author is not very favorably impressed with punch biopsies. In the most difficult cases it is asking too much of the pathologist to express an opinion on so small an amount of tissue.

A further objection to biopsy arises in those cases which are being

cared for at centers where a skilled pathologist is not available. An inadequate pathological opinion is worse than none at all.

In spite of these weighty objections, it is felt that the advantages of biopsy are so great that it should be used frequently. Indeed, in the last three years, it has been the author's custom to perform a biopsy in every case of bone tumor. So far there has been no cause to regret this policy.

SUMMARY

Difficulties in the diagnosis of bone tumors frequently arise. The history and physical examination are often inconclusive. Even the roentgenographic examination may be of uncertain value or definitely misleading. Biopsy is by far the most reliable aid to diagnosis and should be resorted to frequently, with due appreciation of its limitations.

FROZEN-SECTION DIAGNOSIS OF TUBERCULOUS JOINTS

BY WALKER E. SWIFT, M.D., NEW YORK, N. Y.

From the Pathological Laboratory, New York Orthopaedic Dispensary and Hospital

The difficulty of making an accurate diagnosis of joint lesions from the clinical findings, roentgenograms, and usual laboratory tests is becoming more generally recognized by orthopaedic surgeons. Also, the necessity for establishing the correct diagnosis before instituting treatment, particularly in those cases in which tuberculosis is in any way suspected, is becoming more apparent, simply because the forms of treatment applicable to the various diseases are so different.

For these reasons it has been the practice for some years at the New York Orthopaedic Dispensary and Hospital to perform an exploratory operation on those bone and joint lesions in which tuberculosis may be the etiological factor, and to attempt to establish the diagnosis during the operation by microscopic examination of frozen sections. Thus, if tuberculosis is proved, a fusion operation may be performed at once; if tuberculosis is not found, whatever other procedure (if any) is indicated may be carried out with considerable confidence that the right diagnosis is known.

In order to determine the degree of accuracy which may be expected in diagnoses made from the frozen sections of fresh tissue, the following study has been made of 175 such exploratory operations which were done at the New York Orthopaedic Hospital during the years 1928 to 1934 inclusive.

ACCURACY OF PREOPERATIVE DIAGNOSES

The first analysis was made to find how often the preoperative diagnosis was correct when checked with the final pathological diagnosis. It should be stated that the clinical and roentgenographic diagnoses were taken from the hospital charts and in some cases there was difficulty in deciding just what the respective diagnoses were, so that the figures may be subject to some small error.

In 145 of the total 175 cases the clinical diagnosis agreed with the roentgenographic interpretation and was found to be correct 116 times, or 80 per cent. There were twenty-four cases in which the clinical diagnosis disagreed with the roentgenographic reading, and in this group the clinical diagnosis was correct only eleven times, or 45.8 per cent. In a third group of six cases no roentgenographic study had been made and here the clinical diagnosis was correct three times, or 50 per cent.

In other words, the preoperative clinical diagnosis of 175 carefully studied cases of bone and joint lesions was corroborated by the final pathological diagnosis 130 times, or 74.2 per cent. Therefore, it is important to remember that there is at least a 25-per-cent. chance of error in considering the preoperative diagnosis of such lesions.

SITE OF EXPLORATORY OPERATIONS

The disease for which the exploratory operations were performed involved the following regions: knee joint, sixty-eight cases; hip joint, fifty-two; ankle joint, fifteen; shaft of long bone, nine; tarsal joint, eight; wrist joint, seven; tendon sheath, six; shoulder joint, three; elbow joint, three; sacro-iliac joint, two; and metatarsophalangeal joint, two. The location of the lesion did not seem to have any effect on the accuracy of the frozen-section diagnosis, nor did the age of the patients, the youngest of whom was one year old and the oldest sixty-four. However, there was a certain significance in the duration of the disease, as will be indicated later.

AGREEMENT OF FROZEN-SECTION AND PARAFFIN-SECTION DIAGNOSES

It was important to find out how many times the frozen-section diagnosis agreed with the paraffin-section diagnosis, whether or not the latter proved to be the final diagnosis. As expressed in Table I, it was noted that there was agreement in 147, or 84 per cent., of the 175 cases, and that in twenty-eight, or 16 per cent., the paraffin-section diagnosis did not substantiate the frozen-section diagnosis.

TABLE I

AGREEMENT OF FROZEN-SECTION AND PARAFFIN-SECTION DIAGNOSES

Diagnoses	No. of Cases	Per Cent.
Agreement:		
Both diagnoses: Tuberculosis	90	
Both diagnoses: Chronic inflammation	54	
Both diagnoses: Syphilis	1	
Both diagnoses: Giant-cell tumor	1	
Both diagnoses: Acute inflammation	1	
Total	147	84.0
Disagreement:		
Frozen section: Chronic inflammation / Paraffin section: Tuberculosis	23	
Frozen section: Tuberculosis / Paraffin section: Chronic inflammation	5	
Total	28	16.0

There is no comment necessary on the first half of Table I except to say that, in three of the cases diagnosed as chronic inflammation by both sections, guinea-pig inoculation proved tuberculosis to have been present in two, and the third case was proved to be tuberculous at a later operation. In these cases the joints had been diseased for a long time and much scar tissue had formed around them. Undoubtedly the tissue taken for sectioning was outside of the actually diseased area.

The disagreement in diagnoses, as shown in the second half of Table I, is more important. Of the twenty-three cases proved to be tuberculous by paraffin sections, but not by frozen sections, twenty had been diagnosed as tuberculous before operation. In these cases the location of the disease was as follows: hips, fourteen; knees, five; and wrist, one. Although the diagnosis was confirmed in only twelve cases by guinea-pig inoculation, there was no doubt that the diagnosis of tuberculosis was correct. The remaining three cases had been thought to be non-tuberculous before operation, but were proved to be tuberculous by the paraffin sections and the guinea-pig inoculations.

Of the five cases in which the frozen-section diagnosis was tuberculosis, not confirmed by the paraffin sections, all had negative guinea-pig inoculations, and their subsequent course left little doubt that the frozen-section diagnosis was wrong. This is a serious error, and it is clear that, unless the frozen sections demonstrate unmistakable tuberculosis, the pathologist should report only chronic inflammation. The slides of four of these cases have been saved and on further study are thought not to show sufficient evidence for the diagnosis of tuberculosis to have been made.

GUINEA-PIG CORROBORATION OF DIAGNOSIS

Although the histological picture of tuberculosis is a definite one, there is the possibility of faulty interpretation or selection of tissue, and so an attempt to corroborate the section diagnosis by an inoculation of two guinea pigs with pus or tissue from the operative field should always be made.

An analysis of the results of the guinea-pig inoculations in this series showed that there were 133 such tests done, the result corroborating the tissue diagnosis 113 times, or 85 per cent. The diagnosis was not corroborated by eleven guinea-pig tests, and in nine cases the animals died of an intercurrent infection too soon for results to be obtained. It is clear that this method of diagnosis, although important and of a high degree of accuracy, is open to a certain percentage of error and calls for careful selection by the surgeon of tissue for pathological study. Two cases, in which the guinea-pig inoculation proved tuberculosis to be present after the reports of both sections had given the diagnosis of chronic inflammation, have already been mentioned as having old, badly scarred lesions.

COMPLETE ANALYSIS OF FROZEN-SECTION DIAGNOSES

The analysis of the results of the frozen-section diagnoses in the 175 exploratory operations is given in Table II. Under Group A it will be seen that when the clinical diagnosis was tuberculosis, whether or not the roentgenographic interpretation agreed, the frozen section proved the diagnosis in 80 per cent. of 130 cases. When the clinical diagnosis was not tuberculosis, with or without roentgenographic support, the frozen-section diagnosis agreed with the final diagnosis in 89 per cent. of thirty-

TABLE II

COMPARISON OF PREOPERATIVE DIAGNOSES WITH PARAFFIN SECTIONS, FROZEN SECTIONS, AND FINAL DIAGNOSES

Group	Preoperative Diagnoses		Final Diagnosis	Total No. of Cases	Paraffin Section Agreed with Final Diagnosis	Frozen Section Agreed with Final Diagnosis	
	Clinical	Roentgenographic					
					No. of Cases	*No. of Cases*	*Per Cent.*
A	Tuberculosis	Tuberculosis	Tuberculosis	91	88	72	79.1
	Tuberculosis	Not tuberculosis	Tuberculosis	10	10	7	70.0
	Tuberculosis	Tuberculosis	Not tuberculosis	18	18	14	77.7
	Tuberculosis	Not tuberculosis	Not tuberculosis	11	11	11	100.0
Total for Group A				130	127	104	80.0
B	Not tuberculosis	Not tuberculosis	Not tuberculosis	25	25	25	100.0
	Not tuberculosis	Tuberculosis	Not tuberculosis	1	1	1	100.0
	Not tuberculosis	Not tuberculosis	Tuberculosis	11	11	8	72.7
	Not tuberculosis	Tuberculosis	Tuberculosis	2	2	1	50.0
Total for Group B				39	39	35	89.7
C	Tuberculosis	None	Tuberculosis	2	2	2	100.0
	Tuberculosis	None	Not tuberculosis	3	3	2	66.6
	Not tuberculosis	None	Tuberculosis	0	0	0	0.0
	Not tuberculosis	None	Not tuberculosis	1	1	1	100.0
Total for Group C				6	6	5	83.3
Total for Entire Series				175	172	144	82.2

nine cases. When there was no roentgenographic study, the frozen-section diagnosis was correct in 83 per cent. of six cases. A study of this table with the various contradictions of preoperative and pathological diagnoses will serve to emphasize again the inherent difficulty of making an accurate clinical diagnosis of joint lesions.

PREOPERATIVE DIAGNOSES PROVED WRONG

Besides confirming a preoperative diagnosis, frozen sections have been found of great value in showing the clinical diagnosis to have been wrong, and this has meant disproving a suspected tuberculous lesion, as well as proving tuberculosis to be present when it was not expected.

There were thirty-two patients with a preoperative diagnosis of tuberculosis who were proved, finally, to have some other disease, and in twenty-seven, or 84 per cent., the frozen-section diagnosis of chronic inflammation was correct. The other five cases were those which have been mentioned earlier as having been diagnosed as tuberculosis from frozen sections which showed insufficient evidence. The possibility of this error must be stressed, but it is an error which certainly should not occur if the rule is strictly followed of not diagnosing tuberculosis from frozen sections unless the histological picture is unmistakable.

In the case of thirteen other patients, who were thought before operation to have conditions other than tuberculosis—such as chronic infectious arthritis, coxa plana, osteomyelitis or tumor—the diagnosis had to be changed to tuberculosis. This was an interesting group and in nine, or 69 per cent., the frozen-section diagnosis was tuberculosis and was correct, the other four being considered doubtful and therefore called chronic inflammation at the time of the operation.

Thus it may be seen that, of forty-five cases for which a final diagnosis was established differing from the preoperative clinical diagnosis, a correct interpretation was made from the frozen sections in thirty-six, or 80 per cent.

COMPARISON OF FROZEN-SECTION DIAGNOSES WITH FINAL DIAGNOSES

The last criterion for judging the accuracy of frozen-section diagnoses and establishing their value to the surgeon at the operating table is the actual number of times that there may be expected to be agreement with the final diagnosis made after all the evidence has been collected and considered.

The results of this series of examinations are given in Table III, and it is found that when the final diagnosis was tuberculosis the frozen-section diagnosis was correct in 77 per cent. of 116 cases. When there was a final diagnosis other than tuberculosis, the frozen sections gave the right diagnosis in 91 per cent. of fifty-nine cases. In other words, there was an average of 82 per cent. of correct diagnoses made by examination of frozen sections during 175 exploratory operations.

TABLE III

COMPARISON OF FROZEN-SECTION DIAGNOSIS WITH FINAL DIAGNOSIS

Final Diagnosis	Total No. of Cases	Frozen Section Agreed with Final Diagnosis	
		No. of Cases	*Per Cent.*
Tuberculosis	116	90	77.5
Not tuberculosis	59	54	91.5
Total	175	144	82.2

DISCUSSION

The success of frozen-section diagnosis on fresh tissue during exploratory operations depends on three things. In the first place, the surgeon, with the help of the pathologist, must choose satisfactory tissue for sectioning. Random removal of specimens without regard for their gross appearance of disease, particularly in lesions showing a good deal of fibrous-tissue replacement, will surely increase the percentage of failures.

In the second place, the technique of preparing the sections must be satisfactory. Practically all the sections made in these cases were attached to a glass slide after sectioning and then stained with hematoxylin and eosin. The extra five minutes required by this method is compensated by the two advantages of giving a more familiar histological picture and of being permanent, so that the slides may be saved for future study and comparison. Some inflammatory tissues will not cut satisfactorily until after they have been embedded in paraffin and in these cases important parts of the specimen may never be seen in the frozen preparations and the real pathology will be missed. This source of error may be obviated in such cases only by the greatest care and patience in cutting and manipulating the sections.

In the third place, the interpretation of the slides is important and here the main fact to be emphasized is that no tissue should be called tuberculous when there is any ground for reasonable doubt.

Granting that these three requirements are fulfilled, it seems fair to believe, after this study, that the diagnosis made from frozen sections of fresh tissue may be considered correct in 82 per cent. of the cases.

It remains the responsibility of the operating surgeon to decide in the particular case whether or not it falls into the group of 82-per cent. right diagnoses or into the group of 18-per cent. wrong diagnoses. This he must do from his knowledge of all the factors in the clinical history and examination and from his opinion of the gross pathology. A report from the laboratory that the disease is tuberculosis, or, on the other hand, that tuberculosis is not found, should be helpful in making his decision, even

though he may have to conclude that it is necessary to wait longer before being certain of the correct diagnosis.

SUMMARY

1. In a study of the frozen-section diagnoses of 175 exploratory operations on lesions suspected of being tuberculous, the clinical preoperative diagnosis was found to be correct in 74 per cent. of the cases.

2. The frozen-section diagnosis agreed with the paraffin-section diagnosis in 84 per cent. of the cases.

3. Guinea-pig inoculation corroborated the diagnosis in 84 per cent. of the cases.

4. Of thirty-two cases thought to be tuberculous before operation, but proved by sections not to be, the frozen-section diagnosis was correct in 84 per cent.

5. Of thirteen cases thought not to be tuberculous before operation, but later proved tuberculous, the frozen-section diagnosis was correct in 69 per cent.

6. Of the 175 cases, 116 had a final diagnosis of tuberculosis and the frozen-section diagnosis had been the same in 77.5 per cent; fifty-nine cases had a final diagnosis other than tuberculosis and in these the frozen-section diagnosis had been right in 91.5 per cent.

7. Of the 175 cases, the frozen-section diagnosis agreed with the final diagnosis in 82 per cent.

OSTEOCAMP FOR OSTEOTOMOCLASIS

BY DAVID M. BOSWORTH, M.D., NEW YORK, N. Y.
From the Orthopaedic Service, St. Luke's Hospital, New York City

The correction of deformities of bones by osteotomoclasis—simple osteotomy with immediate bending at the site of osteotomy—is occasionally a difficult procedure, even in such favorable locations as the supracondylar region of the femur, due to the tension of surrounding muscular and fibrous structures.

Usually, when the bowing deformity is marked and in locations where soft-tissue structures act as a bowstring, correction by means of simple osteotomy is impossible and wedge osteotomy with removal of a section of bone is necessary. (See Figure 1, *2.*) This decreases the length of an extremity which usually is already short.

For some time the author has felt that osteotomy and the application of an apparatus for gradual correction would permit the stretching of the soft tissues and correction of deformity without loss of length. This possibility has been made almost a certainty by the ease with which a tibia can be lengthened by well-planned and well-carried-out operative procedure.[1]

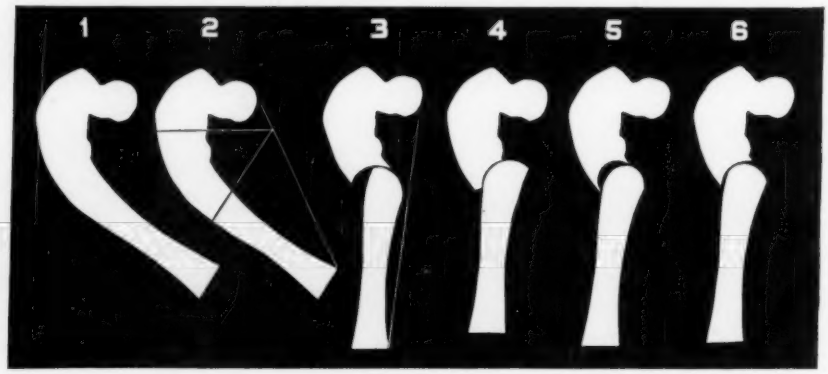


FIG. 1

Effect of different operative procedures to correct bowing deformity.
1: Outline tracing of roentgenogram of original condition;
2: Amount of bone resection necessary to correct position by wedging osteotomy;
3: Defect left if center of curved cut were placed laterally;
4: Projection of fragment if center of cut were placed medially;
5: Gap left if diameter of cut were same as diameter of femur;
6: Optimum contact secured by a cut of a diameter much larger than the femur and centering the curve cut on the center of the femur.

Therefore, an apparatus has been devised for gradually straightening the femur following osteotomy, and this apparatus has been called an osteocamp, since the bowing of a bone is called osteocampsia.

The apparatus consists of hinged arms with a worm gear at the center, solidly fastened to one arm, and a thread, worked by a handle, included rigidly in the other arm. When the handle and thread are turned, the worm gear is driven around slowly, thus changing the angle of the two arms. Two complete units are necessary,—one in front and one in back of the bone. Pin holes are provided through the arms at intervals of one-half an inch for the insertion of three-sixteenths-inch drill-steel pins, and set screws are placed opposite each pin hole to allow the pins to be locked rigidly in place.

The procedure described has been used in the following case:

A young woman, twenty-five years old, of good general bodily health, was seen at St. Luke's Hospital Clinic in the fall of 1932. The patient had fractured the upper right femur three times, at the ages of eight, ten, and eleven years. She had a very marked deformity of the right thigh, due to bowing through a fibrocystic area in the upper femur. With the hip in full abduction and the greater trochanter impinging on the ilium, the right knee lay across the left with the pelvis level. It was impossible for the patient to get her heel to the floor when standing, and the extremity was seven and one-half inches short as measured from the anterior-superior spine to the internal malleolus (Fig. 2, *A*). Genu valgus of 15 degrees was present. A diagnosis of osteitis fibrosa cystica was made, hyperparathyroidism being ruled out.

Roentgenograms showed a medial bowing of the upper half of the femur of 67 degrees and an added coxa vara deformity of the neck of the femur of about 18 degrees, making a total medial bowing of 85 degrees (Fig. 3, *A*).

The difficulties involved—the presence of fibrocystic change in the bone, multiple previous fractures, and danger of infection when working in the upper femoral region near the perineum—were all realized in advance, but the patient was so crippled that an attempt to improve her condition seemed justifiable.

Exact drawings of the femur were made, as shown by roentgenograms, and a curved osteotomy was decided upon in an attempt to

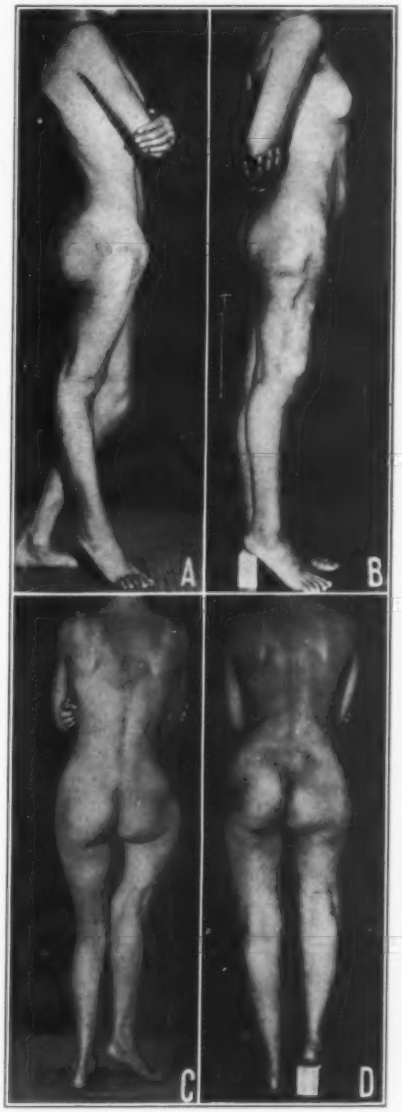


FIG. 2

Showing the amount of correction obtained by the method of osteotomoclasis described.

A and *C:* Original condition with marked lateral bowing and shortening of the thigh as well as anterior torsion, genu recurvatum, and genu valgus.

B and *D:* Correction of all deformities by straightening of the femur. The block beneath the heel is three inches in height.

FIG. 3

Roentgenograms of femora, showing
A: Original condition of right femur;
B: Normal left femur;
C: Corrected right femur.

prevent displacement and allow rotation. It was found that the curve of the osteotomy would need to have a larger diameter than the width of the shaft of the femur to insure the best possible contact following correction and, furthermore, that the center of the osteotomy would need to be in the center of the femoral shaft and not toward either side, in order to give the best cosmetic result. (See Figure 1.) In order to make this curved osteotomy, a semicircular saw (Figs. 4 and 5) was manufactured which could be centered on a drill and which, when rotated back and forth a few degrees, would satisfactorily cut the desired curve.*

Operation, on November 18, 1932, consisted of a lateral incision through very adherent and extensive scar tissue which had resulted from previous operations. Due to the marked curve in the bone, the anterior muscular structures were easily displaced inward. A drill hole was placed at the center of the site selected for operation. The drill was then reversed into the socket of the saw and acted as a pivot to center the saw cut. This gave a curved osteotomy exactly as planned. All soft tissues were then retracted outward to their limits across the bone. Half of the apparatus was laid on the anterior surface of the thigh. This acted as a guide for the placing of two drill holes and two pins through the upper fragment and two drill holes and two pins through the lower fragment, with the center of the gear placed over the center of the osteotomy (Fig. 6).

The incision was sutured and sterile dressings were placed over it and over the point of emergence of the pins, both in front and in back. The halves of the apparatus were placed on the pins anteriorly and posteriorly and locked to the pins by the set screws. When this was done, the fragments were held rigidly in place and the leg could be handled freely without the necessity of any apparatus except the osteocamp. Sliding of the fragments on the pins was prevented by a sterile dressing and sterile felt rings slipped between the skin and the apparatus.

* Following the use of the saw in this case, apparatus for circular osteotomy was described by another surgeon, but the author has been unable to find the original article.

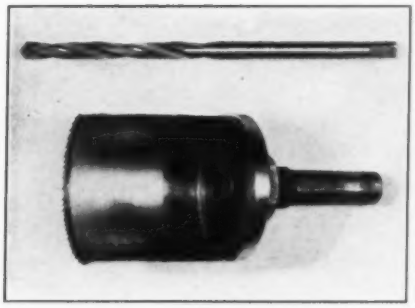


FIG. 4

Showing detail of drill and curved saw.

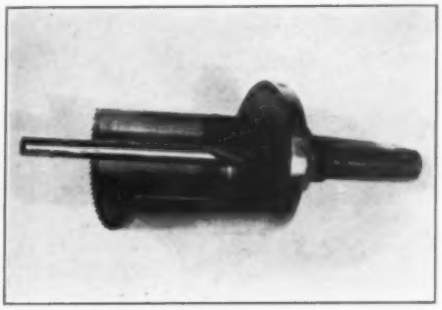


FIG. 5

Showing drill and saw as they would be inserted in the bit-stalk.

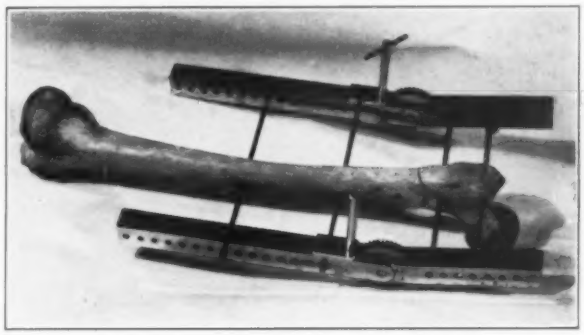


FIG. 6

Osteocamp set up on the femur, as in the case reported. Note the hole for centering and the curved osteotomy.

At the time of operation, a maximum stretching of about 10 degrees only could be secured, due to the tautness of the structures on the inner side of the thigh and the beginning bending of the three-sixteenths-inch drill-steel pins. Correction from 67 degrees to 9 degrees was complete in twenty-two days, a quarter of a turn giving about 2.5 degrees of correction each day.

Maceration of the scar tissue present from previous operations on the lateral surface of the femur took place to a moderate degree, and a hematoma drained through the posterior openings of the upper two pin holes.

The apparatus was removed and plaster was applied (Fig. 7-C) five weeks after the operation, and the cast was kept in place for six weeks. Following the removal of the cast, recurrence of the deformity through the soft callus occurred to the extent of 32 degrees within three weeks (Figs. 7-D, 7-E, and 7-F).

Manipulation under anaesthesia was done (definite soft union being found present) and a plaster spica was applied with the deformity at an angle of 9 degrees (Fig. 7-G). After union had taken place, there was slight absorption, so that four and one-half months later the osteotomy site had become solid at 1.5 degrees. All apparatus was removed at that time.

Infection of the fibrocystic bone at the point of maceration of the suture line in the original scar tissue required a local sequestrectomy a year later (Fig. 7-I). Since that time, there has been no further infection and the patient has been walking on the leg. She suffered a fracture of a fibrocystic patella by indirect violence in November 1934, but otherwise she has had no trouble. Supracondylar osteotomy for genu valgus has recently been done and the patient is walking without support and is greatly improved. Tibial lengthening to overcome some of the remaining shortening is planned.

This case is interesting as a study in reconstructive work. Several new procedures and bits of apparatus were planned out in advance and

successfully used. Such cases are rare, but other instances have occasionally been recorded in the literature.

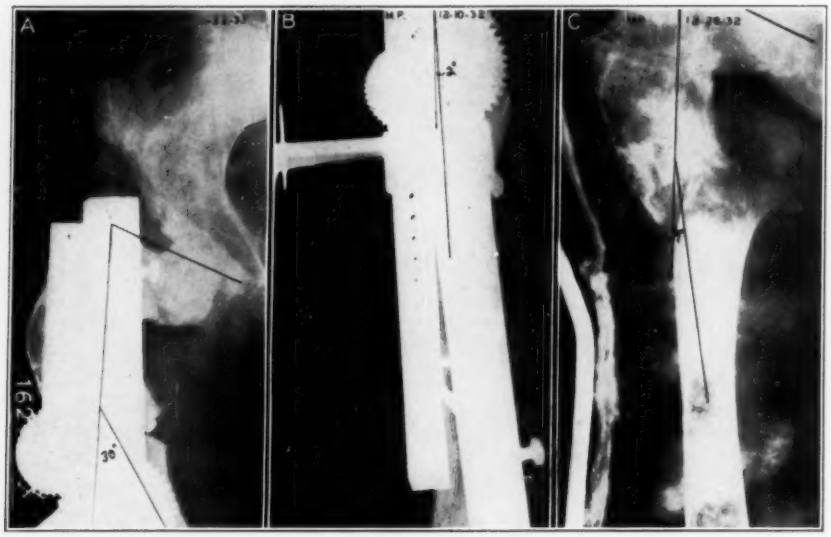


FIG. 7-A FIG. 7-B FIG. 7-C

Figs. 7-A and 7-B: During straightening.
Fig. 7-C: In plaster following straightening. (Compare with Fig. 1, *6*.)

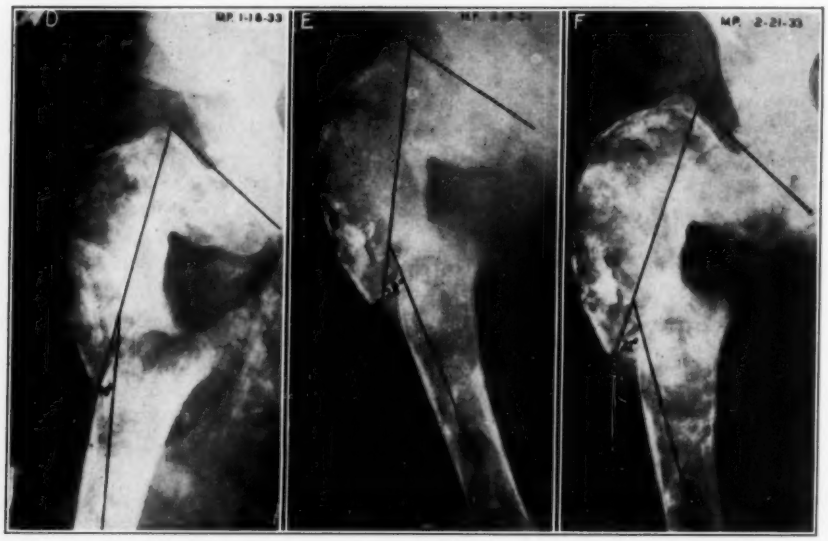


FIG. 7-D FIG. 7-E FIG. 7-F

Recurrence of deformity through soft callus.

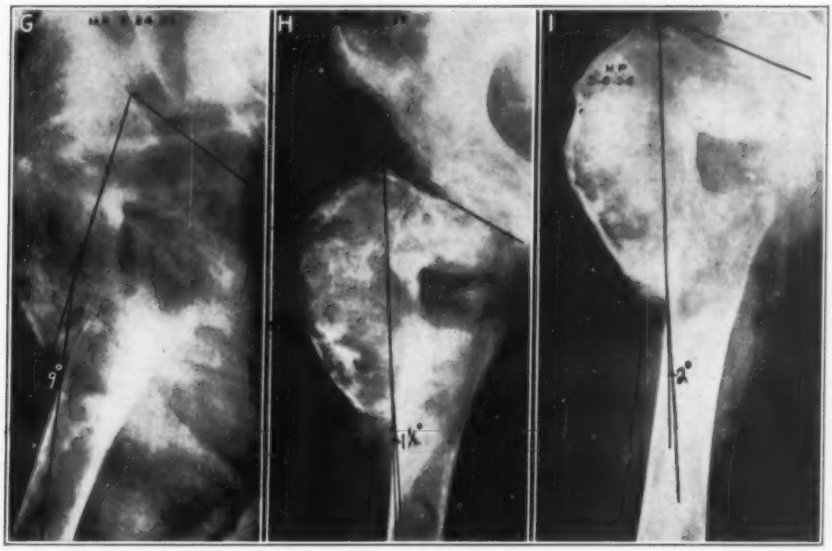


FIG. 7-G FIG. 7-H FIG. 7-I

Fig. 7-G: After manipulation and reduction of deformity.
Fig. 7-H: Following removal of all plaster; union solid but decalcified.
Fig. 7-I: Final result with solid union. There is a decrease in the fibrocystic changes, but a sequestrum is present in the lateral portion of the trochanteric fragment. This was later removed and healing took place.

It is hoped that other orthopaedic surgeons will be encouraged to undertake the reconstruction of similar cases rather than to consider them hopeless as in the past.

1. BOSWORTH, D. M.: Skeletal Distraction. Description of Apparatus. Surg. Gynec. Obstet., LII, 893, 1931.

SOME CONSIDERATIONS ON SUBTROCHANTERIC OSTEOTOMY AND INTRA-ARTICULAR ARTHRODESIS OF THE HIP JOINT

BY ERNST FREUND, M.D., F.A.C.S., VENICE, FLORIDA

A simple transverse osteotomy, if done technically well and according to right indications, is one of the most efficacious procedures in orthopaedic surgery. By this operation in well selected cases, a very beneficial change in the statics of the skeleton may be obtained and the function of the kinetic chain, of which the affected and deformed portion represents only a link, will become greatly improved. In children, because of the very active biological process which favors functional adaptation, the response to a well-healed corrective osteotomy will be almost immediate. Such patients are the best advertisers of our specialty. Lay people marvel at the quick restoration of or improvement in shape and function.

More complicated than the operative procedure is the indication for osteotomy. Besides the degree of disabling deformity, the duration of the deformity and the stage of the disease which caused it have to be taken into serious consideration. If performed too soon or too late after the onset of the disabling disease, an osteotomy may result within a very short time in a complete failure, despite an apparently excellent operative correction of the deformity. It is not sufficient to consider merely the actual amount of deformity which requires correction by osteotomy. The surgeon has to be well acquainted with the disease process underlying and causing the deformity, and he also is obliged to calculate the amount of adaptability of the organism to a change in its statics. The best osteotomy will be futile, if not perilous, if the patient's functional resources have been exhausted in the previous attempt to become adapted to the existing pathological position. Especially beyond the third decade of life, the readiness of the locomotor apparatus to compensate for alteration in form becomes considerably lessened.

In a case in which the deformity is of many years' duration, regardless of whether it is due to a primary joint or bone condition, one has to be very careful in contemplating a corrective osteotomy, especially if there are well established signs of a compensatory rearrangement of the kinetic chain with a satisfactory functional result. The lower extremity with its complicated task of weight-bearing and locomotion is for this reason of greater interest than the arm. Any deformity of the lower extremity will be reflected after a very short period of activity in the vertebral spine. Compensatory curves of the lumbar spine, and later on of higher levels, follow readily the shift or tilt of the pelvis, which is the invariable consequence of any change in the length of the limb, due either to position or to true deformity. This almost automatic readjustment to the best

possible efficiency represents one of the best examples of Payr's idea of a kinetic chain, in which the different links are tightly bound together and any little damage to one link immediately draws all the other portions of the system into participation.

The compensatory realignment is at first purely static and well controlled by muscle action. The pathological curvature of the spine disappears as soon as weight-bearing on the deformed extremity ceases. As time passes, however, the muscular adaptation has an increasingly greater effect upon the skeleton, and the compensatory curves become fixed. This means that a certain quiet physiological derangement has taken place in the complicated joint chain of the vertebral spine with some parts under more marked functional stress and others more or less in disuse. Anatomically this skeletal fixation expresses itself by very definite changes in the joint capsules of the intervertebral joints with shrinkage and thickening of the relaxed portions and comparative atrophy of the overstretched areas. Hand in hand with the changes in the capsular apparatus go structural transformations in the joint ends, especially in the cartilaginous layers of the joint surfaces. Atrophy of the joint cartilage with complete resorption from the joint margins is a most constant finding in those parts which, due to slight subluxation, are out of contact with the antagonist and are, therefore, out of joint play.

Consequently, any corrective osteotomy on the lower extremity (mainly in the trochanteric region) should be performed before skeletal fixation of compensatory (static) spinal curves has occurred,—in other words, before the power of functional adaptation has been fully invested and used up in advanced structural changes. If, in such a stage, the insistence of the patient makes it necessary to perform a corrective osteotomy, the possible benefit from the intervention has to be carefully calculated, and the amount of correction to be given ought to be measured correspondingly. The operation should not be carried out if the functional impairment is not too great and if there is some doubt in the surgeon's mind about the likelihood of improvement. At any rate, the author feels that full correction of the deformity should never be attempted in a case within or beyond the third decade of life, if a flexion-adduction or flexion-abduction contracture of many years' duration has led to a fixed scoliotic and increased lordotic curve of the lumbar spine. The best that can be obtained in such cases is neutral position; often it will even be advisable to leave the limb in a few degrees of adduction. Never should overcorrection be attempted by placing the leg in abduction with the object of compensating for the existing true shortening of the extremity. This procedure, which is as a rule very efficacious in children with limber spines and pelves, is attended by very bad results if performed on adults, whose spines have finally adapted themselves to the faulty statics and display no more regenerative possibilities. Such patients are often not at all benefited by the operation. They may even be much worse after the osteotomy than they were before. The operation, as a rule, has to be

done over again with more approximation to the primary vicious position.

On the other hand, the osteotomy may have been performed too soon at a time when, despite the absence of manifest clinical symptoms, the causative factor of the deformity was still at work. This is true of cases with relatively mild destructive joint lesions in which severe joint contractures may result from intra-articular adhesions or from a more or less localized scarring process of the joint capsule, leading to capsular shrinkage and some muscle spasm. Of especial interest are those cases of destructive (infectious) arthritis in childhood in which, without a more marked degree of destruction, obliteration of the joint space takes place by fibrous adhesions. These cases often show great tendency to joint contractures. The hip joint and the knee seem to be the most frequently involved; the hip joint is apparently affected more often than the knee. The inflammatory process usually subsides under conservative treatment. The concomitant joint contracture, however, represents quite a serious complication in regard to the after-treatment.

As a rule, if there is not too much posterior subluxation of the tibia, a knee-joint contracture can easily be overcome with the aid of traction apparatus or a turnbuckle-cast, and good position can be maintained by a well-fitting long leg brace until the tendency to contracture subsides. Such is not the case with the hip joint. A hip-joint contracture, which is due to fibrous ankylosis following a destructive arthritis, is usually easily corrected by traction. It is, however, very difficult to maintain the corrected position. Single hip spicas or hip braces are of very little help in preventing the quick recurrence of the deformity. The leg draws up, usually to flexion-adduction contracture, and the pelvis accompanies the deformity with a compensatory tilt within the spacious body part of the orthopaedic appliance.

The tendency to contracture following inflammatory joint lesions extends frequently over a period of several years. Clinically, the joint process may appear as healed, but there is still activity with scar formation and muscle imbalance from a pathological view-point. Lorenz, many years ago, in appreciation of this tendency in tuberculous hip disease, suggested the treatment with plaster-of-Paris casts and weight-bearing. He neglected the developing hip deformity entirely and aimed at a solid ankylosis which he hoped would occur under the stimulus of weight-bearing. Once the hip was solid, many years after the onset of the disease, he performed the corrective subtrochanteric osteotomy.

Apart from the questionable occurrence of solid ankylosis in tuberculous hip disease, Lorenz's argumentation seems to be correct. The indication for the osteotomy depends upon the fixation of the contracted position or, in other words, upon the soundness of the destroyed joint. The osteotomy would be futile and the deformity would inevitably recur, if there should still be a tendency to joint contracture. As pointed out, this tendency may be present without any clinical symptoms suggestive

of activity of the disease process. The destruction of the joint alone with the fibrous ankylosis is sufficient reason for the contracture.

Hibbs, approaching the question of tuberculous hip disease from the point of view of uncertainty of permanent cure by the so called conservative treatment, advocated the fusion operation as the treatment of choice and found many followers. It is interesting, however, to find that adduction or flexion contracture does develop in a large number of cases following Hibbs's fusion operation, which otherwise was successful. This bears out the fact that even a strong bone graft placed over the upper side of the hip joint may yield to the persisting pull of muscle spasm and shrinking scar tissue.

It is quite evident that recurrence of the deformity is made easier if the correction of position has been obtained only by the less difficult trochanteric osteotomy and if the joint does not reveal firm bony ankylosis. A relatively short period of time—three to six months—is usually sufficient to show the recurrence of the deformity. In addition to tuberculous lesions, the author has seen a great number of cases of nonspecific hip disease—suppurative synovitis, simple infectious arthritis following open reduction of congenital or traumatic dislocation, etc.—in which an osteotomy had been performed at an apparently quiescent stage of the process with entire immediate success, but the deformity had recurred after a short time.

The following illustrative case was observed in the Orthopaedic Department of the State University of Iowa.

A girl, six years of age, was admitted to the Hospital in July 1931 with bilateral congenital dislocation of the hip joint. She was put in a Hoke-traction cast for five weeks and an unsuccessful attempt at closed reduction was made. Therefore, reduction of the hip by an open operation was tried. This attempt failed also and the secondary acetabulum was reamed out and a bony shelf was built over the head. There was considerable stiffness of the hip following operation. Gradually the right hip went more and more into adduction despite daily physical-therapy treatment and manipulations.

About two years after the shelving operation, a corrective subtrochanteric osteotomy was done. The distal fragment was placed in about 15 degrees of abduction and there occurred good bony union. Nine months after the osteotomy, the hip joint was again held firmly in a position of flexion, 20 degrees of adduction, and 10 degrees of internal rotation. There was no free motion. The roentgenogram showed irregular eroded joint surfaces suggestive of arthritic erosion. The child walked with a marked tilt of the pelvis with extreme lordosis and left convex scoliosis of the lumbar spine. A subcutaneous adductor tenotomy was done to improve the position. The leg could fairly easily be brought out into the straight position. A cast for immobilization was applied for eight weeks.

Half a year later, an extreme adduction contracture had recurred. The hip joint seemed to be stiff on clinical examination, but did not show bony ankylosis in the roentgenogram. Another corrective subtrochanteric osteotomy was performed. After a few months, the same deformity had recurred; the right side of the pelvis was over an inch higher than the left to compensate for the very marked adduction contracture. The roentgenogram showed at the site of the previous osteotomies a pronounced angulation between the upper part of the femur and the diaphysis.

This case, illustrative of the tendency to joint contracture following postoperative (traumatic) arthritis of the hip joint, resisted all attempts at correction by physical therapy, by adductor tenotomy, and by two subtrochanteric osteotomies. Similar cases are by no means rare. They show clearly that the simple subtrochanteric osteotomy, even if the distal fragment is brought into accentuated abduction, is unable to control the tendency to contracture. Such cases certainly require another form of treatment.

One may feel that the osteotomy should be postponed until the joint becomes sound, which means solidly ankylosed. However, it is rather doubtful whether a case will ever go on to spontaneous bony ankylosis, and it does not seem advisable to let the contracture reach its maximum degree. The case just described shows that the tendency to adduction contracture may be present over a number of years, a condition which involves the great danger of spinal deformity. Orthopaedic appliances do not solve the problem for this reason. There would be need of immobilization of both lower extremities to prevent the tilting of the pelvis. In view of the quiescent joint lesion, however, such a rigorous procedure is not warranted.

It seems that the intra-articular arthrodesis is the only logical way out of the difficulties presented by these cases of clinically stiff and painless hips, but without roentgenographic evidence of bony ankylosis. The arthrodesis is indicated for several reasons. When performed by an experienced surgeon, it is a relatively simple procedure which can safely be carried out in thirty minutes. It does not disturb to any marked degree the anatomical condition of the bony joint constituents. It is limited to the complete removal of the joint cartilage and the scar tissue interposed between the joint ends and to the opening of the superficial marrow spaces of the head and the acetabular cavity. It does not affect the epiphyseal plate at the upper end of the femur. This is the main reason why the simple intra-articular arthrodesis is preferable to the extra-articular form with the bone graft, which necessarily blocks the epiphyseal line. It is quite certain that a solid ankylosis, procured by intra-articular fusion, is better able to withstand the pull of the adductor muscles and the shrinking scar tissue. Small reenforcing bone chips, removed from the wing of the ilium, can be placed around the rim of the acetabulum, but not across the epiphyseal plate.

Inasmuch as the majority of these patients are children, quite often with very little bone destruction, the bony ankylosis obtained by intra-articular arthrodesis prepares the way for a possible arthroplasty at a later date. Every subtrochanteric osteotomy, from the standpoint of the osteotomized bone, has to be considered as a poorly healed fracture, in which the kinking of the fragments shortens the bone to a variable degree, corresponding to the amount of deformity to be corrected. It, therefore, represents a disadvantage if an arthroplasty is contemplated later.

ACUTE TRANSVERSE BONE ATROPHY *

BY WALTER G. STERN, M.D., F.A.C.S., CLEVELAND, OHIO

The importance of recognizing acute bone atrophy or, rather, calcium resorption as the underlying cause of many cases of pain and disability of the extremities (Sudeck's atrophy, spotted atrophy, etc.) is being so universally acknowledged that the presentation of another and hitherto undescribed variation of this same phenomenon is not out of order.

After plaster fixation of the limb for fracture of the lower extremity, in young adults between the ages of twenty and thirty-five, the author has often noted a wide and distinct transverse band of radiolucency appearing on the roentgenograms, usually in a position diaphyseal to the union of the metaphysis with the epiphysis,—in the position of the so called "*Gerüstmarkzone*" of infantile scurvy—which, if unappreciated, can lead to a false diagnosis of disease or fracture in this area. This phenomenon has also been observed in three cases of non-suppurative infection in a neighboring joint and in two cases of tumor formation in the limb. The appearance of this transverse zone of bone resorption can best be portrayed in the words of Baetjer in his description of the "*Gerüstmarkzone*" or, as he calls it, "*Trümmer Zone*" in scurvy: "This band produces an appearance on the plate as if a surgeon had roughly operated and removed a narrow cross-section of the bone." The localization of this transverse atrophy is usually peripheral to the site of the injury, but, as King has shown in his latest monograph on bone atrophy, transverse atrophy, like the spotted type of acute or Sudeck's atrophy, can also appear in the bones proximal to the lesion.

The writer has seen fifteen of these cases—at least half as many as he has seen of Sudeck's spotted atrophy—and could further quote many more cases which have been observed by various correspondents who have kindly offered him the histories and roentgenograms of their cases for publication, but which he feels will carry more weight when published by them individually. Unlike the cases of Sudeck's atrophy, which usually occur in the smaller bones, the author's cases, with but one exception, have been confined to the long bones of the lower extremity,—usually to the lower end of the tibia. There have also been three cases of transverse atrophy at the upper end of the tibia and the lower end of the femur,—one through the neck of the femur (horizontal) and another vertically through the neck of the scapula.

The following cases are typical of this form of atrophy.

CASE 1. A male, aged twenty-three, on "poor relief" for the past three years, whose diet had consisted chiefly of cheap carbohydrates with sufficient proteins and fats, but with very little fresh fruit and few vegetables, tripped on the floor of his home in Novem-

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 14, 1936.

ber 1934 and received a transverse fracture of the fibula, about one inch from the lower end, and a vertical crack fracture of the internal condyle of the tibia. With the exception of these changes, the roentgenographic examination (Figs. 1 and 2) was negative. The usual biochemical blood and urine tests, including phosphorus-calcium ratio, were negative. The patient had more than the ordinary number of carious teeth, but ascribed this to the fact that the family were on "poor relief" and consequently he had not had dental care for several years.

The patient was immediately placed upon a diet rich in vitamin C, and a circular plaster cast with a walking iron was applied. He was then encouraged to walk about, first on his crutches and then without them. He seemed unwilling to do this because of pain in the ankle and swelling of the toes.

When the cast was removed, five weeks after the injury, a wide, transverse, sharply defined, radiolucent band of bone absorption was noted in the roentgenograms just proximal to the usual occurrence of Guérin's line (Fig. 3). There was no trophoedema of the leg, foot, or ankle; the color of the parts was normal. There were no pressure marks from the cast, which had been fairly heavily padded. The usual tests for sufficiency of the arterial circulation gave normal results.

Six weeks later a second check-up roentgenogram showed a decrease in the intensity of the rarefaction. A final roentgenographic examination, made three weeks later, still showed the band, but much less distinctly (Figs. 4 and 5).

CASE 2. A male, aged twenty-two, had been ill in bed for four months with pain in the left thigh and knee, and was said to have had fever and night sweats for one month. Early roentgenograms were reported to have shown a "loosening of the lower epiphysis" of the femur. The swelling had slowly subsided.

At the time of the author's examination, six months after the onset of the process, the left knee was symmetrically swollen and held in a position of 45 degrees of flexion. Further flexion of 45 degrees was free and unimpeded. Complete flexion and extension

FIG. 1

FIG. 2

Fig. 1: Case 1. Arrow points to fracture of the fibula. This is not a persistent epiphyseal line as shown by the healing in Fig. 4.
Fig. 2: Case 1. Arrow points to fracture of the tibia.

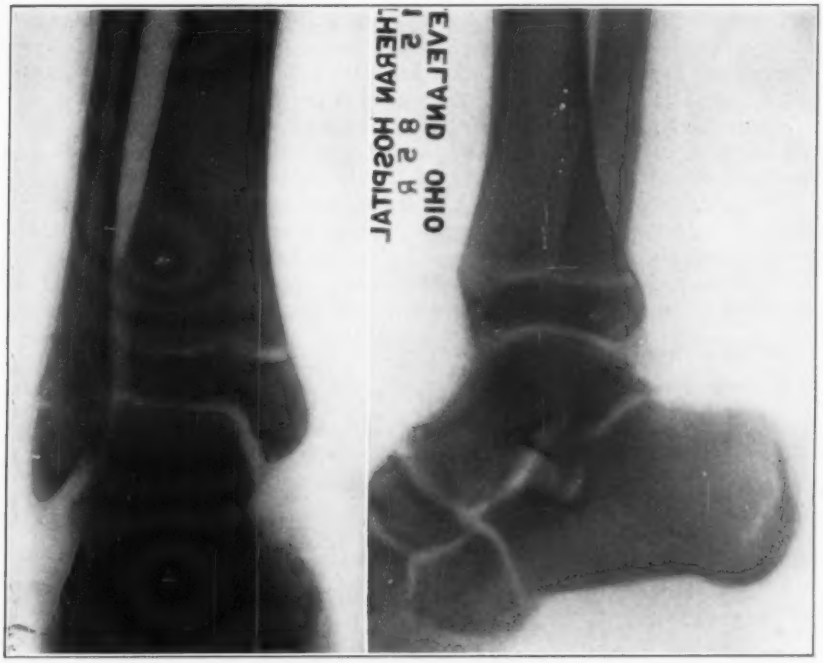


FIG. 3

Case 1. Lower part of the tibia five weeks after injury.

FIG. 4

Case 1. Transverse atrophy of the lower end of the tibia nine weeks after Fig. 3. Note healing in the fibula.

FIG. 5

Case 1. Transverse atrophy of the lower end of the tibia nine weeks after Fig. 3.

were impossible and attempts at such motion were quite painful. There was no free fluid in the knee joint, and no especial areas of tenderness about the knee joint. The hip was negative. Differential tuberculin tests and the usual laboratory biochemical tests were negative. The phosphorus-calcium content of the blood was normal.

Roentgenographic examination showed a mild generalized atrophy of the tibia and fibula, in addition to which there was a marked transverse band of decalcification just diaphyseal to the epiphyseal line both of the tibia and of the fibula (Fig. 6).

The patient was given an anaesthetic, and the knee was straightened out and fixed in plaster. After a short time, a walking caliper brace was used. The patient was given sun baths, fresh air, and a high-caloric and high-vitamin diet.

Roentgenograms taken six months later showed that the atrophy had practically disappeared. The patient is making steady and uninterrupted progress toward recovery.

A most unusual and bizarre combination of symptoms occurred in the following case.

CASE 3. A young woman, aged twenty-three, slipped and fell early one morning while at work, striking her buttocks. She arose, went about her duties as a clerk, and did not feel the need of medical aid on account of her injury.

Two weeks later she suffered from a severe quinsy sore throat and, before she had

FIG. 6

Case 2. Transverse atrophy in the tibia and femur after acute non-suppurating arthritis.

completely recovered, she was seized with a sudden, sharp, excruciating pain in the hip of the same side which she claimed to have injured. She was put to bed by her attending physician. After three weeks at home, she was transferred to a hospital. A roentgenogram of the hip was taken and was found to be negative in all respects. Buck's extension was then applied. A diagnosis of gonorrhoeal arthritis was made, although the patient denied ever having had intercourse, and cervical and urethral smears, as well as the gonorrhoeal complement-fixation tests, were negative.*

Six months later a second roentgenogram was taken and was also pronounced negative. However, the author believes one can see a narrowing of the joint space, destruction of the cartilage of the upper pole of the hip joint, and a faint transverse line of radiolucency running through the lower part of the neck of the femur.

After five months' rest in bed and fixation, the hip was stiff and painless. A third roentgenogram revealed further destruction of the cartilage of the hip and a wide, well-defined transverse band of radiolucency extending through the lower part of the neck of the femur, from the head of the femur through the trochanter (Fig. 7).

A diagnosis of ununited fracture of the femur was then made, and the case was certified for industrial accident insurance, which the insurance carrier refused. Finally, a compromise was effected and the patient was sent for observation to one of the major surgical clinics, where the diagnosis of ununited fracture was concurred in. A bone-graft operation was advised and refused, and in the spring of 1934 the patient returned to her home.

She gained rapidly in health and well-being, so that by fall of the same year the insurer believed her capable of going back to her former occupation of store clerk. She refused, claiming disability because she could not bend her hip to sit down in comfort. She again visited the surgical clinic for operative advice and an arthroplasty was decided upon. This, however, was refused by the insurer and the employer. The patient was then sent to the author for examination, estimation of disability, and advice as to treatment.

FIG. 7

Case 3. Transverse atrophy of the neck of the femur.

The entire medical history and hospital records accompanied her and, in spite of the insistence now that her disability followed at once upon her injury, the medical sequence of affairs was absolutely clear and was as given here in brief. Excellent roentgenograms in proper sequence were found in the legal file, all properly labeled and identified.

Examination showed a solidly ankylosed hip—painless and symptomless—and the

* The author believes the acute phase of this case is somewhat like that form of acute arthritis which he described at the Minneapolis meeting of the American Medical Association as "acute, painful, ankylosing arthritis" and which others (he believes mistakenly) held to be gonorrhoeal. Repeated vaginal examinations and smears revealed an intact hymen and no purulent discharges. The urethral and cervical smears were negative, as were also the precipitation and gonorrhoeal complement-fixation tests.

patient walked so well in her high heels that with her clothes on it was hard to tell from her gait that she even had an ankylosed hip. The final roentgenograms showed a solidly ankylosed hip. The line of transverse atrophy had entirely disappeared and there was no angular deformity, overriding, or shortening such as one would expect even with a spontaneous fracture.

This is distinctly not one of those cases of spontaneous fracture in this region which have been reported, especially by Milkman. These spontaneous fractures, of course, never heal and the post-mortem findings show an increasing vascularity in the zones of transverse transparency, which, according to Milkman, suggest some trophic disturbance (Looser Zone).

While the ultimate cause of bone atrophy in general is still shrouded in considerable mystery or only hazily surmised, we are now positive of one thing, and that is that bone atrophy is not caused by circulatory deficiency. Bone is considered to be one of the most unstable of all tissues, since lime is being constantly absorbed and redeposited in equal amounts. The thought that deficient circulation led to deficient calcium deposit and bone reproduction was, of course, enticing, but it has been shown by a host of experimenters and writers—among whom are Key, Phemister, Murray, and Harris—that where the blood supply is cut off, as for instance in the case of a fracture of the head of the femur, calcium resorption or bone atrophy does not take place.

The experiments of Leriche and others show: that a normal circulation results in normal bone calcification; that an excessive supply of blood to the part, plus an unknown factor, causes bone resorption; and that a diminution of blood supply results in sclerosis. Even here some of the moderns, as for instance Axhausen, Destat, Presier, Kienböck, and others, tend to "backslide" a little when they attempt to explain the sharp localization of post-traumatic atrophy in some of the carpal bones. As King has so succinctly stated, "It is probable, however, that both the bone resorption and the vascular dilatation are the result of an alteration in the conditions present in the part, the exact type and degree of alteration and its cause being still uncertain." He also claims that the experimental production of a typical "acute bone atrophy" has not yet been achieved by anyone. Phemister, the author believes, also agrees to this.

Can it be that the unknown factor at work in these cases of bone atrophy is the same as is seen in certain generalized diseases of childhood—rickets and especially scurvy—in which bone atrophy or, rather, calcium resorption plays such an important rôle, and in which, through the lack of certain vital principles of nutrition (called by Burrows "ergusia", now better known as "vitamins"), orderly bone growth and metabolism are interfered with and calcium is lost from certain specific areas? In one of his papers Hess remarks: "Occasionally oedema rather than hemorrhage has been found in the scurvy of adults." As before stated, could one but reproduce experimentally in adult animals the conditions here under discussion, the problem might be easily solved. The improvement

in several of our cases after having been placed on a high-vitamin diet must be looked upon merely as a coincidence, however enticing it may be to speculate upon cause and effect.

SUMMARY

Attention is called to the occurrence of a form of acute bone atrophy seen in young adults, usually after fixation of a limb for fracture. This phenomenon has also been seen by the author in four cases after disuse because of non-purulent infection in neighboring joints, and in two cases of tumor formation in the limb. This type of atrophy takes the form of a broad translucent band of bone resorption on the diaphyseal side of the epiphyseal line, parallel to the axis of the neighboring joint. This band occupies the same position as does a similar band of radiolucency in scurvy, which is sometimes called "*Trümmer Zone*", "*Trümmerfeld Zone*" (Baetjer-Windberger-King), or "*Gerüstmarkzone*" (Harris-Lehndorf). This peculiar form of atrophy should not be mistaken for fracture or acute disease.

An unusually complete and extensive bibliography on this subject is contained in the latest publication by Dr. E. S. J. King, of Melbourne, Australia. Other authors who are not included in Dr. King's bibliography, but who have contributed to our knowledge of this type of atrophy, are: Baetjer and Waters, Burrows and Johnston, Fraenkel and Gorey, Ghormley, Goldblatt, Gurd, Harris, Jones and Roberts, Karsner, Milkman, Murray, Phemister, and Williams.

REFERENCES

Baetjer, H. A., and Waters, C. A.: Injuries and Diseases of the Bones and Joints: Their Differential Diagnosis by Means of the Roentgen Rays, pp. 191, 192. New York, P. B. Hoeber, Inc., 1921.

Burrows, M. T.: Studies to Determine the Biological Significance of the Vitamins. Proc. Soc. Exper. Biol. and Med., XII, 241, 1925.

Burrows, M. T., and Johnston, C. G.: The Action of Oils in the Production of Tumors. With a Definition of the Cause of Cancer. Arch. Int. Med., XXXVI, 293, 1925.

Fraenkel, Eugen, und Gorey, Alexander: Archiv und Atlas der normalen und pathologischen Anatomie in typischen Röntgenbildern. Die Rachitis im Röntgenbild. Hamburg, L. Gräfe & Sillem, 1910.

Ghormley, R. K.: Nelson Loose-Leaf Living Surgery, III, 4, 5. New York, Thomas Nelson & Sons.

Goldblatt, Harry: Die neuere Richtung der experimentellen Rachitisforschung. Ergebn. d. allg. Pathol. u. path. Anat., XXV, 58, 1931.

Gurd, F. B.: Post-Traumatic Acute Bone Atrophy (Sudeck's Atrophy). Ann. Surg., XCIX, 449, 1934.

Posttraumatic Acute Bone Atrophy. A Clinical Entity. Arch. Surg., XXXII, 273, 1936.

Harris, H. A.: The Growth of the Long Bones in Childhood. With Special Reference to Certain Bony Striations of the Metaphysis and to the Rôle of the Vitamins. Arch. Int. Med., XXXVIII, 785, 1926.

Bone Growth in Health and Disease: The Biological Principles Underlying the Clinical, Radiological and Histological Diagnosis of Perversions of Growth and Disease in the Skeleton. New York, Oxford University Press, 1933.

JONES, R. WATSON, AND ROBERTS, R. E.: Calcification, Decalcification, and Ossification. British J. Surg., XXI, 461, 1933–1934.

KARSNER, H. T.: Human Pathology. Ed. 4, p. 884. Philadelphia, J. B. Lippincott Co., 1935.

KING, E. S. J.: Localized Rarefying Conditions of Bone as Exemplified by Legg-Perthes' Disease, Osgood-Schlatter's Disease, Kümmell's Disease and Related Conditions. London, Edward Arnold & Co., 1935. Baltimore, William Wood & Co., 1935.

LOOSER, E.: Über Spätrachitis und Osteomalacie. Klinische, röntgenologische und pathologisch-anatomische Untersuchungen. Deutsche Ztschr. f. Chir., CLII, 210, 1920.

MILKMAN, L. A.: Multiple Spontaneous Idiopathic Symmetrical Fractures. Am. J. Roentgenol., XXXII, 622, 1934.

MURRAY, C. R.: Healing of Fractures. Its Influence in the Choice of Methods of Treatment. Arch. Surg., XXIX, 446, 1934.

PHEMISTER, D. B.: Repair of Bone in the Presence of Aseptic Necrosis Resulting from Fractures, Transplantations, and Vascular Obstruction. J. Bone and Joint Surg., XII, 769, Oct. 1930.

STERN, W. G.: Acute, Painful Ankylosing Arthritis. J. Am. Med. Assn., XCI, 1253, 1928.

WILLIAMS, J. W.: Obstetrics. Ed. 6, p. 746. New York, D. Appleton and Co., 1931.

SCOLIOSIS: ITS PROGNOSIS

BY JOSEPH C. RISSER, M.D., PASADENA, CALIFORNIA AND
ALBERT B. FERGUSON, M.D., NEW YORK, N. Y.

From the New York Orthopaedic Dispensary and Hospital

For the past 100 years there has been much confusion regarding the natural course of scoliosis. Many ideas have been expressed which have been based on impressions rather than on actual examinations of the patient or his deformity.

In order to arrive at an opinion based on accurate measurement, all of the untreated cases of scoliosis with standard roentgenographic examinations and growth measurements at the New York Orthopaedic Dispensary and Hospital have been studied. There were 296 cases (57 males, 239 females). Measurements of height, while sitting and standing, and roentgenograms in the erect and recumbent postures were included in the examination of every patient. Curvature was measured in the roentgenogram as described in a previous paper[1].

No case was omitted because of severity of curvature. If the patient was not suitable for surgical treatment, but did return for subsequent examinations, he was included in this study. In the erect posture, 52 per cent. of the curvatures measured from 20 to 40 degrees; 20 per cent., from 40 to 60 degrees; 9 per cent., from 60 to 80 degrees; and 5 per cent., more than 80 degrees.

Right-dorsal left-lumbar curves were present in 78 per cent. of the cases, and left-dorsal right-lumbar curves in 22 per cent.

The fifty-one paralytic cases (18 males, 33 females) comprised 31.5 per cent. of the males and 13.8 per cent. of the females.

The age of cessation of rapid vertebral growth of adolescents was determined from forty-seven cases observed in and after the growth period. In this group, growth in sitting height ceased on the average at the age of sixteen and one-third years in males and fourteen and one-fourth years in females. The extremes of age were: in males, fourteen years in two cases, seventeen years in four cases; in females, twelve and one-half years in one case, thirteen years in ten cases, and sixteen years in three cases. In each case curvature increased during the growth period and not thereafter.

Twenty-nine other patients seen during the adolescent growth period have not yet ceased growing, but have not exceeded the average or the maximum of the above group.

One hundred and thirty-four patients were seen after cessation of vertebral growth, but before the maximum age for arrest of growth. In these growth was known to have ceased in the eighteen males at the age of fifteen and one-half years on the average, the extremes being fourteen

and seventeen years, and in the 116 females at the age of fourteen and one-third years on the average, the extremes being twelve and sixteen years. In no case was there an increase in the curvature.

The findings in these cases indicate that cessation of vertebral growth and arrest of progress of curvature may be expected at or before the age of seventeen in males and sixteen in females.

Two hundred and fifty-five cases were observed after growth in height had ceased. Twenty-two of these cases were observed less than one year. These cases conform to the findings of the group as a whole, but are hereafter disregarded because of the short period of observation. The forty-seven cases followed through the adolescent growth period were observed thereafter for an average of three and two-tenths years for the males and two and eight-tenths years for the females, the longest period being eight years for each sex. Increase in sitting height per year during this period averaged eight hundredths of an inch in males and one-tenth of an inch in females. This is within the limit of error of measurement. At the same time, standing height increased per year three-tenths of an inch in males and two-tenths of an inch in females. In no case was there an increase in the curvature.

One hundred and eighty-six cases, first seen when growth in height had ceased, were observed from one to eleven years, the average being two and three-fourths years. Twenty-one of these were observed more than five years. In no case was there an increase in the curvature during the period of observation.

While in none of the 255 cases was there an increase in curvature after cessation of vertebral growth, increase was regularly observed during the growth period. This relation is shown in the following: The forty-seven cases examined during the period of rapid growth and thereafter were observed on the average two and one-tenth years before growth had ceased, the longest periods being five years in four males and eight years in one female. During this growth period, the average yearly increase in curvature was 5.9 degrees in males and 8.2 degrees in females. At the same time the average yearly increase in sitting height was forty-four hundredths of an inch in males and nine-tenths of an inch in females; in standing height, ninety-four hundredths of an inch in males and one and seven-tenths inches in females.

The twenty-nine patients who did not complete their growth during the period of observation were younger. At the start of observation the males averaged eleven and one-third years and the females, twelve years. The average duration of observation was three years in the eleven males and two and six-tenths years in the eighteen females. The average yearly increase in curvature was 5 degrees in males and 8 degrees in females. The greatest yearly increases were 10 degrees in a male in the age group from twelve to sixteen years, 19 degrees in a female with collapse of the lung, in the age group from thirteen to fifteen years, and 13 degrees in a female in the age group from thirteen to fifteen years. Increase in curva-

ture was slight at the ages from five to ten years. The usual yearly increase in sitting height was one-tenth to four-tenths of an inch at ages from four to twelve in males and from three to eight in females; one to one and one-half inches at ages from twelve to fifteen in males and from ten to fourteen in females.

The observations that have been cited indicate that rapidity of increase of curvature corresponds with rapidity of vertebral growth, and that increase of curvature ceases when growth in sitting height ceases,—that is, not later than seventeen years in males and sixteen years in females. The etiology of the curve did not affect its relation to growth. In cases of paralysis and of hemivertebrae, and in those due to unknown causes, the curvature increased with growth and remained stationary when growth ceased.

Of the 296 cases in this study, twelve were regarded as exceptional and are not included in any of the groups described. In six of these, there was no increase in the curvature within the age period from ten to sixteen, although the average yearly increase in sitting height was nine-tenths of an inch. In another case, there was no increase in curvature from the age of seven to the age of thirteen, although sitting height increased six and nine-tenths inches in this time. These were all mild curves.

In two cases of marked kyphosis there was an increase in the angle of curvature at or after cessation of growth. This was believed to be due to enlargement of the kyphos rather than to increase of the lateral curvature. In another case the curvature increased after the age of thirteen, but the interval between examinations was too long to determine when the increase occurred.

One case was exceptional in that there was some decrease in the curvature between the ages of ten and sixteen.

Another patient wore corrective plaster jackets until he was eighteen and one-half years of age. Thereafter until he was twenty-one and one-half years of age his curve increased from 67 to 75 degrees. This is not an untreated case, but is included to illustrate that when the spine is held up by plaster it may be expected to sag when the plaster is removed, regardless of age.

It has frequently been stated that flexibility of the spine causes scoliosis to become worse. The fact that exercises maintaining flexibility are usually begun at the age when the curve is increasing because of rapid growth may be the basis for this belief. Many patients in this series had postural exercises, including some flexibility exercises, but in no case was there an increase in curvature after cessation of vertebral growth. One girl with a curvature of 70 degrees was a gymnasium teacher for eleven years, during which time there was no increase in deformity. Another girl, aged fourteen and one-half, with a curvature of 75 degrees, was an acrobatic dancer. She had a very flexible spine. She has continued vigorously her acrobatic dancing with no increase of deformity. She was last seen at the age of sixteen and one-half.

CONCLUSIONS

Growth in vertebral height ceases in girls at or before the age of sixteen, the average age being fourteen; in boys, at or before the age of seventeen, the average age being sixteen.

Increase in curvature in scoliosis ceases when vertebral growth stops.

The spine grows slowly in boys from the ages of four to eleven, and in girls from the ages of three to nine; but growth is rapid in adolescence. Rapidity of increase of curvature corresponds to rapidity of growth.

The relation of increase of curvature to growth is not materially influenced by the etiology of the curve.

The effectiveness of various methods of treating scoliosis for prevention of progress of curvature must be judged in adolescent patients who have not ceased growing. After growth has ceased, treatment for this purpose is superfluous.

1. Hibbs, R. A., Risser, J. C., and Ferguson, A. B.: Scoliosis Treated by the Fusion Operation. An End-Result Study of Three Hundred and Sixty Cases. J. Bone and Joint Surg., XIII, 91, 1931.

INFLAMMATORY LOCALIZED LESIONS OF THE JUXTA-EPIPHYSEAL ZONE OF THE NECK OF THE FEMUR

BY DR. DOMENICO LOGRÒSCINO, TRIESTE, ITALY

From Ospedale Marino di Oltra, Croce Rossa Italiana*

TRANSLATED FROM THE ITALIAN BY ERNST FREUND, M.D., VENICE, FLORIDA

Localized lesions of the neck of the femur, due to tuberculosis or to common pyogenic organisms, have long been recognized and studied by anatomists, while they have still remained hidden from the clinicians in the huge group of inflammatory hip diseases. To roentgenology belongs the credit for having shown the way in the research and definition of finer clinical symptoms, so that gradually a typical clinical picture with a true nosological entity could be made out. Localized lesions of the neck of the femur were described by Sourdat (1909) in a purely roentgenographic study and by Waldenström (1908–1910) in several articles in which he published the results of very careful anatomical, roentgenographic, and clinical investigations. Later on, with the perfection of technical means, the progress of physical symptomatology, and the development of more accurate roentgenographic and clinical diagnoses, the recognition of these lesions became more frequent. At present, however, the interest in juxta-articular lesions has greatly decreased, because their clinical and roentgenographic appearances have become so well known. In the interpretation of clinical facts, it has been necessary to concentrate more on etiology and pathogenesis.

After making arteriographic studies of the normal vascularization of the neck of the femur in different ages, the author has been able to deter-

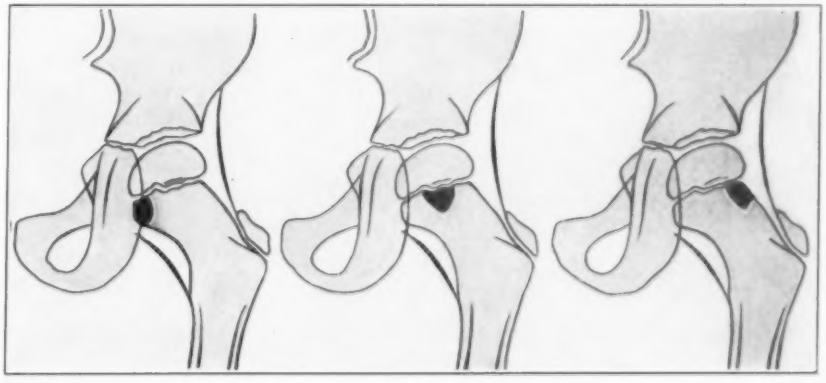


FIG. 1

Showing the three areas in the juxta-epiphyseal zone in which the inflammatory lesions are usually localized.

* Prof. A. Mezzari, Director.

mine why such localized tuberculous lesions are frequently found in children but do not occur in adults. With these findings, it has been possible to differentiate lesions of varying localization which correspond to a definite topographical and anatomical pathology and also to the clinical picture. Thus, four principal types of localized tuberculous lesions of the neck of the femur have been distinguished as follows: (1) foci in the lower cervicodiaphyseal arch; (2) foci with juxta-epiphyseal localizations; (3) foci with bulbometaphyseal localizations; (4) foci with metaphyseal-subtrochanteric localizations.

In this paper, the author wishes to discuss the juxta-epiphyseal localizations, using as a basis the cases seen at the *Ospedale Marino "Elena Duchessa d'Aosta"*. To the lesions due to the tubercle bacillus, other interesting but lesser known pyogenic lesions have been added. Thus it is possible to point out the differential facts in the early symptomatology and in the clinical course, and to draw practical conclusions of great importance. The following cases are presented in the hope that they may contribute to a clearer understanding of the nature of these lesions.

FIG. 2

Case 1. M. A., a boy, nine years of age. Tuberculous focus in the inferomedial portion of the juxta epiphyseal zone.

FOCI IN THE INFERO-MEDIAL PORTION

CASE 1. M. A., a boy, nine years of age. During the year previous to admission the hilar lymph nodes had enlarged and moderate pain of intermittent character had appeared in the region of the right hip, accompanied by fatigue and a limp.

At examination the patient's general condition was found to be fair. There was enlargement of the lymph nodes in the right groin. The right lower extremity was externally rotated and there was tenderness on pressure over the head of the femur and the greater trochanter. Motion was present as follows: flexion, 110 degrees; internal rotation, abduction, adduction, and hyperextension, slightly limited.

A roentgenogram (Fig. 2) revealed a focus in

the inferomedial portion of the juxta-epiphyseal zone, partially defined by reactive perifocal sclerosis. Otherwise, the findings were normal.

Diagnosis: Tuberculous focus in the lower portion of the neck of the femur.

Treatment consisted of immobilization. Panarthritis developed fourteen months after the patient's admission to the hospital.

FOCI OF THE INTERMEDIATE TRACT

CASE 2. D. B., a boy, four years of age. Three months before admission a slight limp had developed. The child was easily fatigued, but suffered no pain. During the month prior to admission, there was marked pain in the right hip, associated with a limp, rapid loss of weight, and fever.

The boy appeared pale and emaciated. The right hip joint was swollen and hot. There was extreme tenderness to direct and indirect palpation. Weight-bearing was possible and gait was painless with a limp.

Roentgenographic examination (Fig. 3) showed the acetabulum and joint space to be normal. The head of the femur was markedly osteoporotic. The upper epiphyseal plate was irregular with hazy outlines. A very dark, shadowlike sequestrum was present in the intermediate portion of the juxta-epiphyseal zone, surrounded by a dense zone and moderate perifocal reaction.

Diagnosis: Tuberculous focus of the intermediate portion of the juxta-epiphyseal zone.

Two months later panarthritis developed. Three months after admission an abscess formed in the upper corner of Scarpa's triangle and broke through after two more months.

Treatment consisted first of immobilization in a plaster cast. Fourteen months later, an operation was performed in which the sequestrum was removed and the wound was closed. The patient is still under treatment.

CASE 3. G. G., a boy, three years of age. At the age of six months, tenderness had

FIG. 3

Case 2. D. B., a boy, four years of age. Tuberculous focus in the intermediate portion of the juxta-epiphyseal zone.
A: September 19, 1932. *B:* March 27, 1935.

FIG. 4

Case 3. G. G., a boy, three years of age. Old suppurative arthritis of the right hip. Osteomyelitic focus in the intermediate portion of the juxta-epiphyseal zone.

been noted over the region of the right hip. The patient had started to limp at the age of fourteen months. Physical examination disclosed a pathological dislocation of the right hip, and this diagnosis was confirmed by roentgenogram.

Treatment consisted of open reduction of the right hip. Eight months after operation, following a boil on the back, stiffness appeared in the left hip. The hip was cool, dry, and painless, and was held in moderate abduction. Motion was present as follows: flexion-extension, 30 degrees; abduction and adduction, 10 degrees; rotation, 5 degrees.

FIG. 5

Case 4. DeC. F., a boy, five years of age. Tuberculous focus in the superolateral portion of the juxta-epiphyseal zone.

X-rays (Fig. 4) showed the upper end of the right femur to be well placed at the outer edge of the acetabulum. A dense wedge-shaped shadow suggesting a sequestrum, surrounded by a zone of osteoporosis, was present in the metaphysis of the left femur. There was moderate perifocal reaction, and expansion of the joint capsule was noted. There were no signs of porosis.

Diagnosis: Osteomyelitic focus in the intermediate portion of the juxta-epiphyseal zone without joint invasion.

FOCI IN THE SUPEROLATERAL PORTION

CASE 4. DeC. F., a boy, five years of age. One and one-half months before admission moderate pain had appeared in the right hip, associated with a persistent limp and a poor appetite. No fever was present and there were no general symptoms.

At examination, the general condition was fair. The right lower extremity was kept in external rotation and 20 degrees of flexion. The hip region was cool, dry, and not tender. Motion in the hip was as follows: flexion-extension limited to 10 degrees; abduction, to 30 degrees; internal rotation, nil; other movements normal. There was no shortening. Atrophy of the thigh, amounting to one centimeter, was noted.

Roentgenographic examination (Fig. 5) revealed in the superolateral portion of the juxta-epiphyseal region a sharply outlined focus with small spots of increased density in the inner portion. A double zone of perifocal reaction could be seen,—one area was located immediately around the focus and the other was situated farther away in the metaphysis. The capsular shadow was slightly expanded. Signs of an old mediastinal pleurisy were evident on the right.

Diagnosis: Tuberculous focus of the superolateral portion of the juxta-epiphyseal zone.

Treatment consisted of immobilization. Three months after admission to the hospital, the lesion was still circumscribed and had not invaded the joint. There was, however, some capsular thickening. Moderate pain was elicited on pressure over the whole area. Motion was as follows: flexion, 85 degrees with pain in the last degrees; adduction, 5 degrees; abduction, 15 degrees; internal rotation, one-third of normal; external rotation, complete. No abscesses were present. There was a distinct limp and the leg was held in a position of abduction and outward rotation.

FIG. 6

Case 5. F. G., a boy, sixteen years of age. Tuberculous focus in the superolateral portion of the juxta-epiphyseal zone.

CASE 5. F. G., a boy, sixteen years of age. One year before admission he had suffered an injury to the region of the right hip. One day later fever had appeared, accompanied by local pain and redness. The patient had been given rest in bed for three months. He had then been permitted to get up although the limp and pain in the hip persisted. After three months two sinuses had appeared below the greater trochanter, one of which was still discharging on admission.

The right lower extremity was in normal position and there was no shortening. There was full range of motion in the extremity.

Roentgenographic examination (Fig. 6) showed a round focus of circumscribed osteoporosis in the superolateral portion in the juxta-epiphyseal zone. There was also evident a channel-like band of bone resorption, which started in the most inferior point of the focus of rarefaction and extended toward the greater trochanter. Very little perifocal reaction was noted. The joint space was slightly decreased.

Diagnosis: Tuberculous focus in the superolateral portion of the juxta-epiphyseal zone.

Treatment consisted of immobilization. During an observation period of six months several soft-tissue abscesses and other bony lesions of tuberculous nature developed. The motion in the hip joint became considerably restricted. The muscles atrophied and a slight limp appeared.

CASE 6. M. A., a girl, two years of age. Six weeks before admission a high fever had developed and there was pain in the right hip region.

Physical examination showed the child to be in fair general condition. There was lymphadenopathy in the groin. The hip was kept in 15 degrees of flexion, 5 degrees of external rotation, and 10 degrees of abduction. It was slightly swollen and very tender on pressure. Motion was present as follows: 90 degrees of flexion, 10 degrees of abduction, 10 degrees of adduction, 10 degrees of external rotation, no internal rotation. There was no shortening, but atrophy of the hip muscles was evident. The patient limped and maintained the hip in a slightly flexed and adducted position.

Roentgenographic examination showed osteoporosis and slight narrowing of the hip-joint space. The capsular shadow was expanded upward. A radiotranslucent zone with an irregular outline was present in the superolateral portion of the neck. This zone extended into the interior portion in the form of a slightly darker area, and occupied three-fourths of the neck of the femur. A shadowlike sequestrum, with hazy outline and complete absence of reactive sclerosis, was seen in the inner portion of the neck. There was elevation of periosteum along the diaphysis (Fig. 7).

FIG. 7

Case 6. M.A., a girl two years of age.

Diagnosis: Tuberculous focus in the superolateral portion of the juxta-epiphyseal zone.

Treatment consisted of immobilization. Panarthritis developed six months after admission.

CASE 7. N. B., a boy, four years of age. Five months before admission a high fever had developed, associated with extreme pain in the left hip, which became fixed in flexion. The temperature remained elevated for about one month. Treatment had consisted of traction and a plaster cast.

On admission, the patient's general condition was poor. Motion was present as follows: flexion, 30 degrees; abduction, 15 degrees; and slight external rotation. Swelling of the thigh was noted and there was slight pain on pressure over the head of the femur. Some passive motion was possible. There was no fever.

Roentgenographic examination (Fig. 8) revealed that the upper epiphyseal plate, especially on the medial side, was not sharply outlined. There was a wedge-shaped lesion, like an infarct, in the upper lateral portion of the juxta-epiphyseal zone, surrounded by sclerosed bony tissue which had lost its normal trabecular structure. Periosteal and endosteal reactions extended downward along the diaphysis, especially on the inner side.

FIG. 8

Case 7. N. B., a boy, four years of age. Osteomyelitic focus in the superolateral portion of the neck of the femur.

Diagnosis: Osteomyelitic focus of the superolateral portion of the juxta-epiphyseal zone.

Treatment consisted of incision and drainage of the hip region and curettage of the bony cavity. Thick pus with staphylococcus citreus was evacuated.

The patient was discharged one month after operation in excellent general condition. The hip had healed and was only slightly limited in abduction and flexion.

LOCALIZATION

The roentgenograms of the cases presented show clearly that the inflammatory processes in the juxta-epiphyseal zone of the femoral neck may have three localizations,—the inferomedial, the intermediate, and the superolateral positions. It seems that the interposed areas are immune and become involved only by expansion of the lesions in the neighborhood.

These inflammatory changes in the neck of the femur develop mostly

at a certain age, from two to eight years. They are rare from eight to twenty years of age, and, if present beyond this age, they are almost always of different etiology and origin.

If it is admitted that the usual mode of infection of bony lesions is embolic through the arterial system, the explanation of these facts can be obtained only by accurate knowledge of the anatomy of the vessels in these regions. The juxta-epiphyseal region of the femoral neck obtains its blood supply in childhood, the period of the greatest frequency of the disease, as follows:

1. By a terminal artery which passes superficially the spongy bone of the inferomedial portion of the neck and ends in the superior region of the epiphysis;

2. By a terminal artery which reaches the epiphysis through the intermediate portion of the neck;

3. By a terminal artery which ramifies in the superolateral portion of the neck.

These arteries are terminal in children; in adults they anastomose, beginning at the end of the growth period. Thus the typical and constant localization of inflammatory lesions and their occurrence in a certain period of life are easily explained.

ANATOMICAL AND ROENTGENOLOGICAL ASPECTS

In addition to the site, the morphological aspect of the lesions in the early stage of their manifestation aids in demonstrating the intimate relationship between localization and lesion.

Quite frequently the shape of an infarct can be noted in the roentgenogram. The focus is more or less triangular in shape with a wide base toward the epiphyseal plate and the point toward the metaphysis (Fig. 1). This, however, is true only in the beginning of the process when the focus is still well circumscribed. It is especially prominent in tuberculosis because of the chronic and slow character of the disease. It is difficult to demonstrate a wedge-shaped focus in diseases of more acute character with rapid invasion, as in pyogenic lesions (Fig. 4).

In both types of inflammation, pyogenic and tuberculous, the earliest stages yield only a picture of slight spotted atrophy which becomes evident mainly by comparison with the normal side. Although of greatest importance from the therapeutic viewpoint, it is frequently very difficult, purely on the basis of roentgenographic findings, to differentiate the tuberculous lesions from those caused by other organisms. It is generally agreed that the diffuse bony atrophy and the absence of more marked periosteal and endosteal reactions are characteristic of tuberculous lesions, while the opposite picture obtains for pyogenic osteomyelitis. This holds true for the majority of cases but not for all cases.

The main reason for this is that the bony tissue reacts to each bacterial agent in a very different way. Consequently, the roentgenograms show diverse conditions, depending upon the virulence of the germ, the

varying intensity of the disease process, and the different reactions of the organisms. If the tubercle bacillus shows marked signs of virulence and the reaction of the organism is active, as is quite often the case in childhood, then the roentgenogram may reveal features which usually are considered as characteristic of non-specific inflammatory lesions. Furthermore, if we consider that the juxta-epiphyseal lesions are always situated very superficially, even subchondrally, we will understand that elevation of periosteum will occur not only in pyogenic but also in tuberculous lesions, because of the immediate surrounding reaction.

Neither can greater significance from a diagnostic viewpoint be attributed to the precocious formation of sequestra, because they occur in both affections with the same frequency. Thus Case 2 (Fig. 3) and Case 3 (Fig. 4) could, from a roentgenological viewpoint, be attributed to one affection as well as to the other; whereas Case 6, although tuberculous in nature, could have been included in the group of simple osteomyelitic lesions, because of the marked periosteal reaction.

Among the indirect signs of the focus is the frequent expansion of the joint capsule superiorly and inferiorly with restriction of the joint space (Lange). This sign indicates the increase of synovial fluid in the joint cavity caused not by germs but by toxic irritation from the bony focus. The widening of the joint capsule on the upper side of the joint can easily be visualized if the roentgenogram is taken with soft rays and without a reenforcing filter (Figs. 4, 5, and 6).

The inflammatory lesions of the juxta-epiphyseal zone rarely remain circumscribed. As a rule, they break into the hip joint after a shorter or longer period during which they preserve sharp outlines.

The analysis of the different forms of evolution of these lesions is interesting. As in any other localization, the appearance of the focus is followed by a halo of perifocal sclerosis, which in an early stage is weak and only partial. It demarcates the focus and arrests or retards its evolution.

These zones of reaction may gradually become quite marked; this is true not only in the pyogenic forms (Fig. 8) but also in tuberculous lesions (Fig. 3). They vary from case to case and influence the further development of the lesion. Interesting in this respect was Case 4 (Fig. 5) in which an annular band of sclerosis was present immediately around the focus and another band, at a greater distance, involved a large part of the metaphysis. Of even greater interest was Case 5 (Fig. 6). Here, the inflammatory process, on its way to the surface, had formed a tunnel which partially destroyed the epiphyseal cartilage of the greater trochanter and led to the formation of an abscess and a fistula without invading the joint.

The juxta-epiphyseal lesions can be differentiated from others in the immediate vicinity by some peculiarities which are caused by the involvement of the epiphyseal disc. The poorly vascularized cartilage of the epiphyseal plates, rarely directly involved in a disease process, is very sensitive to every toxic or bacterial agency during the period of its greatest activity. Despite the fact that the foci are situated very close to the

epiphyseal line, the process very rarely directly attacks or destroys this area. Case 2 (Fig. 3) showed this remarkable resistance of the epiphyseal cartilage which, although involved in the disease process (as could be seen by its hazy configuration in the roentgenogram), became only attenuated and atrophic during the two years' duration of the disease. Otherwise it appeared to be healthy with a linear and sharp shadow. Proof of its function is found in the facts that the bony segment had continued to grow and that the bony focus had become displaced downward in the metaphysis (Fig. 3, *B*).

The involvement of the epiphyseal cartilage, which is determined with difficulty even by the expert eye and which is perceptible only in technically perfect roentgenograms, is revealed by direct and indirect signs. Among the first of these should be mentioned the contraction of the bony portions which are separated by the plate. However, the chief signs are the haziness and irregularity of its usually clear-cut and distinct linear image (Figs. 2, 3, 4, and 6). Among the indirect signs one of the most constant and important is a bony condensation at the epiphyseal side of the destroyed portion of the cartilaginous plate. This is sometimes very slight and almost imperceptible. These observations were confirmed by autopsy in one case studied at the *Istituto Ortopedico Rizzoli*.

If the alterations of the spongy bone below the epiphyseal plate are marked, and if also the blood vessels from which the epiphyseal cartilage obtains its nutrition by imbibition are involved, important changes in shape will result.

In the following case, which had been under careful observation for years, a gradual slipping of the epiphysis toward the superolateral portion of the neck occurred, leading to a certain degree of coxa vara epiphysaria.

CASE 8. B. M., a girl, eleven years old. In addition to other suppurative lesions, the patient had an involvement of the right hip. The roentgenogram (Fig. 9, *A*) showed complete separation of the epiphysis. Its bony density was slightly higher than normal. The periosteum along the diaphysis was elevated.

Diagnosis: Osteomyelitic focus in the juxta-epiphyseal zone with epiphyseal separation.

Closed reduction was attempted with only partial success, and the hip was immobilized in a plaster spica. Four months later, the hip was still swollen, hot, and painful. The roentgenogram (Fig. 9, *B*) showed the same position of the epiphysis, which appeared dense and sequestrumlike in its upper half. After three more months of immobilization, the roentgenogram (Fig. 9, *C*) revealed that only small sequestrated fragments of the epiphysis remained. A sinus had opened in the groin and was discharging profusely. Hip drainage, with sequestrectomy, was performed. One month later, the incision had healed and the hip was solid and in good position (Fig. 9, *D*).

The functional disturbance which results from juxta-epiphyseal lesions has been discussed on another occasion. Its chief effect is noted on the growth of the extremity which is stimulated in the first period and inhibited in later stages. Also, the development of the cephalic epiphysis may become hastened or retarded according to the stage of the bony lesion.

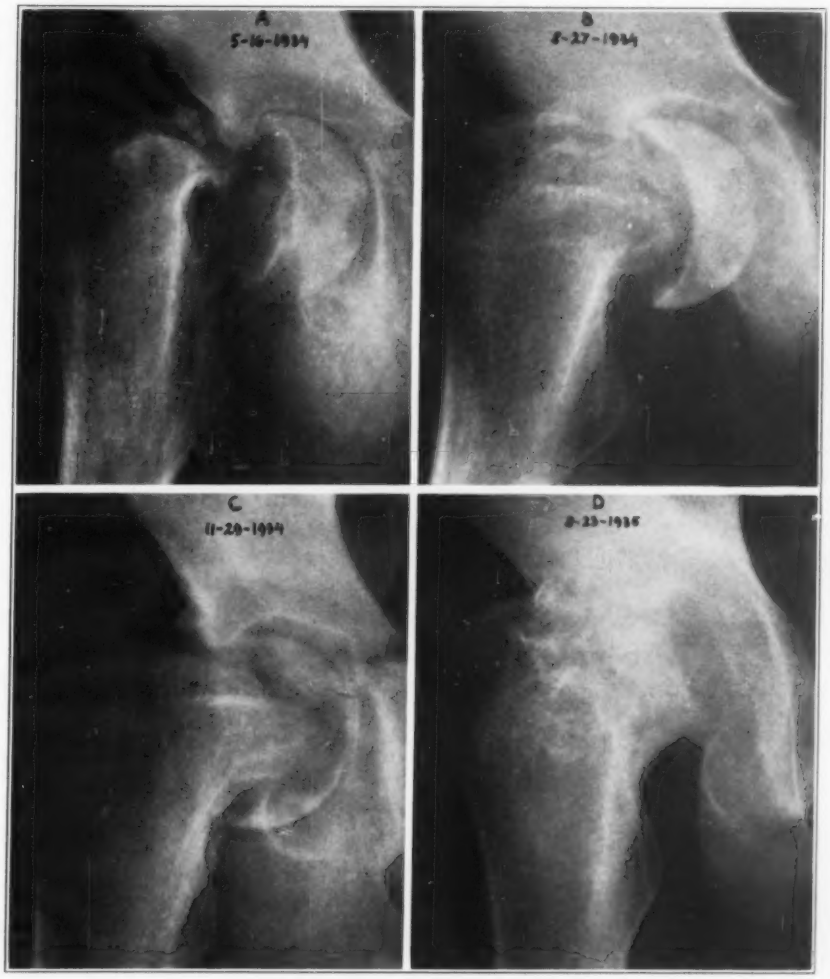


FIG. 9

Case 8. B. M., a girl, eleven years of age. Osteomyelitic focus in the juxta-epiphyseal zone with epiphyseal separation.
A: May 16, 1934. *B:* August 27, 1934.
C: November 29, 1934. *D:* August 23, 1935.

SYMPTOMATOLOGY AND COURSE

It has been stated before how treacherous and difficult may be the interpretation of the roentgenograms of the juxta-epiphyseal lesions from a diagnostic standpoint. We shall now consider the positive signs which are revealed by physical examination and the characteristic symptoms of each type of lesion.

The limitation of motion, active as well as passive, is an early sign of involvement of the synovial membrane and this symptom should be analyzed with the greatest care. It is almost always related to the bony

lesion and can, therefore, aid in the localization of the bony focus. There always results limitation of that type of motion which causes tension on the periosteum and the joint capsule overlying the inflammatory lesion. For this reason, in some cases in which the joint cavity has not yet become invaded (Cases 4, 6, and 7), the extremity assumes a certain rest position in order to relax the joint capsule over the diseased region.

If the focus is in the inferomedial portion, the leg is kept in adduction, slight flexion, and external rotation. For the most part, these cases show marked limitation of abduction and flexion. In cases with foci in the intermediate portion, there is an obstacle to external rotation and abduction.

Limitation of internal rotation is characteristic in cases with foci in the superolateral portion of the neck. Internal rotation is affected first and in the greatest degree (Cases 4, 5, 6, and 7). Later, and to a minor extent, follows the limitation of flexion and adduction. Pain, due to muscle spasm from periosteal irritation, is a frequent symptom when motion is forced in the direction in which it is mainly limited.

Tenderness on pressure is present over the deep part of the inguinal fold in cases with foci in the inferomedial portion of the femoral neck. In cases with lesions of the superolateral portion, tenderness is noted over the middle point of the spinotrochanteric line.

Palpation furnishes other signs of a more general significance, such as increase of skin temperature, sometimes very slight and transient, and thickening of the joint capsule, which as long as the joint cavity is not invaded is probably due to toxic irritation of the synovia. In one patient (Case 4), deep palpation of the joint gave the impression of dense, elastic consistency, like leather under moderate tension.

Another sign which cannot be overlooked because of its frequent occurrence is unilateral inguinal lymphadenopathy, the presence of which always makes one suspicious of a bony lesion in the neighborhood.

Finally, the hypotonia of the musculature associated with, but almost always preceding, the hypotrophy is a sign of indubitable value in favor of an organic hip lesion.

In a very early stage of the affection, associated with these two factors more than with the pain, is limitation of weight-bearing on the affected extremity, resulting in a very slight limp which is more easily recognized by the ear than by the eye.

In cases with foci of the superolateral portion, the use of the limb for weight-bearing is allowed in slight external rotation (Cases 4 and 5). Among the periarticular muscles the glutei are the most hypotonic and hypotrophic and frequently produce a positive Trendelenburg sign.

Tuberculous lesions, as well as pyogenic osteomyelitic lesions, can manifest themselves by such symptoms. Therefore, the differential diagnosis is very difficult in cases in which the history, biological reactions, and the clinical course do not aid. (See Case 3.)

There are definite cases of simple osteomyelitis which simulate tuberculous lesions, and there are even more frequently tuberculous lesions which

have a clinical picture and course that commonly are considered as typical of acute and subacute pyogenic osteomyelitis.

The author wishes to consider here some details which have not been mentioned by other writers who have occupied themselves with the subject. It frequently happens after trauma that a tuberculous lesion develops, accompanied by high fever, redness, swelling, increase of local temperature, marked limp, rapid decline of the general condition, and inability to bear weight. Such was the clinical picture in Cases 5 and 6. Case 5 was proved to be tuberculosis by the appearance of sinuses and other skeletal lesions, by the biological reaction, and by the clinical course. The juxta-epiphyseal lesion remained localized in the cancellous bone of the neck. The acute clinical picture with which this affection was associated cannot, therefore, be explained as a sudden invasion of the joint cavity. The same is true of Case 6, which also was complicated by the appearance of sinuses and the destruction of the joint ends. It, nevertheless, was a case of simple tuberculous osteo-arthritis in which the focus remained circumscribed for a period of at least six months.

It may be mentioned finally that, if there is lacking sufficient evidence of an endocrine influence, it is possible to confuse an idiopathic epiphyseolysis with a tuberculous or osteomyelitic lesion.

TREATMENT

The greatest exactness of diagnosis is necessary, not only in a general way, but also as to localization and to the stage of the development. This is of great practical importance because the treatment of pyogenic osteomyelitic lesions has to be conducted in a different way from that of tuberculous lesions, the treatment of which depends upon the stage of evolution.

In lesions caused by pyogenic organisms, surgical treatment is frequently absolutely necessary to obtain a good anatomical and functional result. In the initial stages with moderate virulence, the routine conservative treatment may be sufficient,—that is, traction followed by immobilization of the diseased joint (Case 3). As in tuberculous lesions, so also in these cases spontaneous regression and healing may occur, although not very frequently.

In other instances surgical treatment may give brilliant results, as in Case 7, in which the intervention was performed at the right moment and the hip was saved from the imminent invasion. Healing occurred with almost complete motion which still persists five years after the onset of the disease.

These are the cases in which surgery is the treatment of choice. However, there are also other cases in which operation is indispensable, such as Case 8 in which the epiphysis, separated from its source of nutrition, became absorbed on one side and sequestrated on the other. Due to the suppuration maintained by the sequestra and the inability of the limb to bear weight, surgical intervention became necessary.

As far as the tuberculous lesions are concerned, the author has discussed them on other occasions and wishes to mention only those points which have been brought out by the cases described. Conservative treatment, if instituted early and conducted well, is the only treatment capable of giving good results in these cases. This is the frequently expressed opinion of the writer's teacher, Prof. Putti, which is based upon his long and extensive experience. Of the fifteen cases which the author has studied and treated by immobilization in the *Istituto Rizzoli*, cure has been obtained in six cases. Cure by surgery is possible, but is usually illusory and frequently ephemeral, especially if the follow-up examination is made a number of years after operation. The author has seen patients, who had been operated upon and considered cured by their surgeons, enter the hospital with a fully developed panarthritis. The reasons for the bad results are multiple, and, since much has already been written in regard to them, they will not be discussed here.

REFERENCES

LANGE, MAX: Die Erleichterung der Frühdiagnose der Koxitis durch bisher wenig beachtete Veränderungen im Röntgenbild. Ztschr. f. orthop. Chir., XLVIII, 90, 1927.

LOGRÒSCINO, D.: La tubercolosi del collo del femore. Chir. d. Org. di Movimento, XIX, 295, 1934.

SOURDAT, PAUL: Étude radiographique de la hanche coxalgique, en particulier chez l'enfant. Paris, Thèse de Paris, 1909.

WALDENSTRÖM, H.: Die operative Behandlung von Tuberkulose im Schenkelhals. Ztschr. f. orthop. Chir., XXII, 581, 1908.

Der obere tuberkulöse Collumherd. Ztschr. f. orthop. Chir., XXIV, 487, 1909.

Die Tuberkulose des Collum femoris im Kindesalter und ihre Beziehungen zur Hüftgelenkentzündung. Stockholm, P. A. Norstedt & Söner, 1910.

THE END RESULTS OF THE FRACTURED DISTAL TIBIAL EPIPHYSIS

BY ALEXANDER P. AITKEN, M.D., BOSTON, MASSACHUSETTS

There seems to be a great difference of opinion as to the end results of fractures of the epiphyses. We apparently know little about such injuries, although their occurrence is by no means rare. In discussing this subject, most writers have considered fractures of the epiphyses as a group. We believe that we can no more classify all epiphyseal fractures in one group, as to end results, than we can classify the end results of fractures of the clavicle with those of the os calcis. This fact is obvious when one recalls that the epiphyses vary greatly in their anatomical structure and physiological function. Furthermore, the location of an epiphysis determines to a great extent its susceptibility to injury. Such factors as size, shape, and position of the epiphysis, the amount of growth which the epiphysis contributes, and weight-bearing are all of importance. To arrive at accurate conclusions, then, we must consider each epiphysis individually.

In order that our conclusions may be accurate, we must have accurate statistics. A review of the literature shows that this prime requisite has been overlooked. In most instances the authors have reported a small series of cases which they have followed for a time. To these they have usually added several cases of deformity which have come to their clinics from suburban or rural districts. A high percentage of poor end results is thus obtained. It should be obvious that we cannot get a true picture of end results if we add to our series only the poor results which have come from another source. Although our series is not large, it is presented with the hope that others will investigate this subject and furnish accurate statistics on the true results of these injuries.

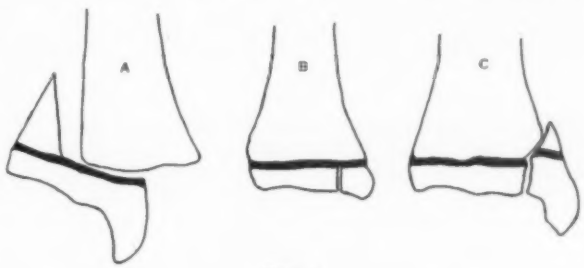


FIG. 1

Diagrammatic drawing showing usual types of fractures:
A: Type 1. The fracture line runs parallel and proximal to the cartilage plate (heavy black line) through the newly formed bone and emerges through the shaft. There is no fracture of the cartilage plate itself. The entire epiphysis is displaced *en masse*.
B: Type 2. The fracture line crosses the bony epiphysis from the joint to the cartilage plate, but there is no fracture through the plate. In about 40 per cent. of the cases the plate is crushed.
C: Type 3. The fracture line runs through the bony epiphysis, the cartilage, and the shaft.

At the Boston City Hospital, a series of twenty-one cases of fractured distal tibial epiphyses have been studied. These patients have been

FIG. 2-A

Marked displacement in a patient fifteen years of age. This was incompletely reduced.

reexamined at periods of from two to ten years from the date of injury. There were two female and nineteen male patients. The ages varied from six to sixteen years. There were four cases in which the patients were nine years of age or younger. The majority of cases occurred between the eleventh and the fifteenth years. In this group there were sixteen cases.

In a study of end results, we must not only consider each epiphysis individually, but we must also bear in mind that each epiphysis is subject to different types of fractures, the end results of which vary greatly. In this series, we have found that the distal tibial epiphysis is subject to three distinct types of fractures, the end results of which differ considerably. In order to understand these fractures, it is necessary to consider the epiphysis as consisting of three distinct layers,—the bony epiphysis, the cartilaginous plate, and the layer of newly formed bone between the cartilage plate and the shaft proper.

In the first type (Figs. 1, *A* and 2-A), the fracture line runs parallel and proximal to the epiphyseal cartilage through the newly formed bone. There is usually a chip fracture of the shaft, but no fracture of the epiphysis itself can be seen by x-ray. The epiphysis is thus shunted off *en masse* with little or no damage. This type is the most common and usually shows the greatest displacement.

In the second type (Fig. 1, *B*), the fracture line crosses the bony epiphysis from the joint to the cartilage plate. There is no fracture of the shaft and usually there is very slight, if any, displacement. In our cases the line apparently did not cross the cartilage; consequently the epiphyses suffered little or no damage. McFarland, however, states that in 40 per cent. of his cases of this type of fracture the plate was crossed and deformity resulted. We believe this figure to be more accurate, as it is derived from a larger series than ours.

In the third type (Figs. 1, *C*, 3-A, 4-A, and 5), the fracture line enters the epiphyseal cartilage from the joint, crosses the cartilage, and penetrates the shaft. Displacement is usually slight. In our series, the fracture line was seen on the medial side of the epiphysis. In this type

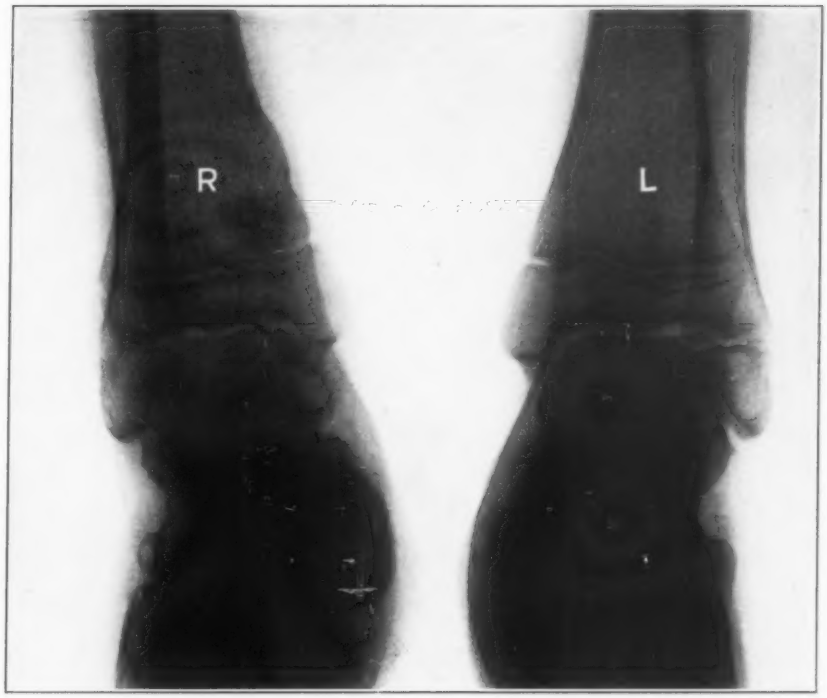


FIG. 2-B

Same patient shown in Fig. 2-A, two years later. Note absence of deformity. There is, however, some thickening as compared with the opposite side.

FIG. 3-A

FIG. 3-B

Fig. 3-A: Type-3 fracture. This was not reduced.

Fig. 3-B: Same patient shown in Fig. 3-A, three years later. Note correction of displacement and absence of deformity, but evidence of retardation of growth at fracture site.

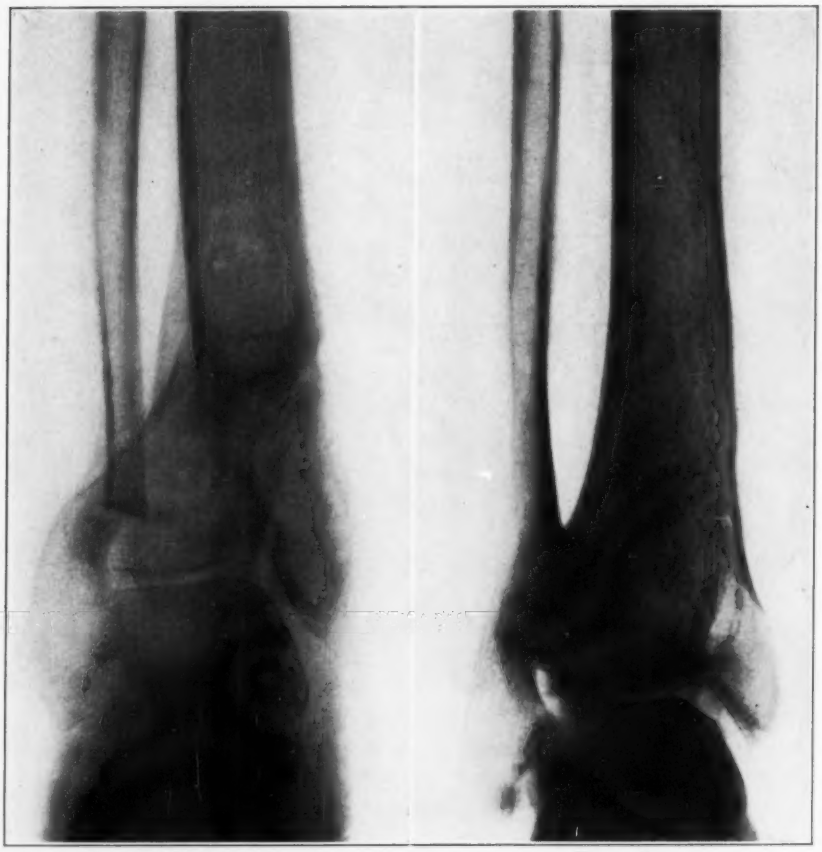


FIG. 4-A FIG. 4-B

FIG. 4-A: Type-3 fracture. Roentgenogram after osteotomy for varus deformity. (Operation performed by Dr. Joseph Shortell of Boston City Hospital.) Note evidence of old fracture lateral to internal malleolus.

FIG. 4-B: Roentgenogram taken five years later than Fig. 4-A, showing excellent result.

of fracture the cartilage plate is not only fractured, but in most cases it is crushed.

Of the first type of fracture, there were sixteen cases. In ten of these the displacement was associated with fractures of the shafts of the tibia and the fibula. In two instances the fibula only was fractured, while in four cases the epiphysis was displaced without fracture of either shaft. The type of displacement varied. In most cases displacement occurred laterally downward. In other cases the epiphysis was displaced either medially or anteriorly or posteriorly. In twelve of these cases there was some displacement on discharge from the hospital. In none of these cases can displacement be seen at the present time, nor is there any evidence of deformity. In eight cases, ossification is already complete. In two cases, in which the patients are sixteen and eighteen years of age, ossification is nearly complete. In six cases ossification has not yet begun.

The youngest patient in the latter group is twelve years of age, and it is now six years since his injury. Also in this group are two cases of two years' duration in patients sixteen and seventeen years of age who are near the age of normal ossification. In the remaining three cases the patients are over fifteen years of age, and it is three years or more since the date of injury. It is highly improbable, then, that deformity will occur at this late date in those cases in which ossification has not yet taken place.

Because of the difficulty of including the whole lower leg in a roentgenogram, we have not been able to measure accurately our patients for shortening. Although some undoubtedly have some slight shortening, this cannot be detected clinically in any of the cases.

As we found in our study of the distal radial epiphysis, premature ossification does occur. In two cases the injured epiphysis has already ossified, while the epiphysis of the opposite side has not yet completely closed. We believe that in the great majority of cases of this type of fracture this premature ossification is of little clinical significance.

FIG. 5

Patient had Type-3 fracture. Roentgenogram shows ossification of medial third of the epiphysis and developing varus deformity nine months after injury. (Case of Dr. F. J. Cotton.)

In the second group of fractures there were three cases. One of these patients had a fracture of the lateral quarter of the bony epiphysis with displacement, but without fracture of the shaft. In this case the epiphysis is now ossified without deformity, but some lateral displacement can still be seen. There has been no interference either with growth or with function. Two patients had fractures of the medial third of the bony epiphysis without fracture of the shaft. In one of these cases the epiphysis is now ossified; in the other, that of a boy eleven years of age, the fracture is of two years' duration. In neither case is there deformity, clinical shortening, or evidence of retardation of growth at the fracture site.

Of the third type, there were two cases. In one of these the whole fragment was displaced *en masse* medially and upward (Fig. 3-A). An attempt at reduction failed, but no evidence of displacement could be seen three years later (Fig. 3-B). There was no shortening and no deformity, but growth had been definitely retarded at the fracture line. This patient is now fifteen years of age and the epiphysis will probably ossify before deformity can develop. The second patient had a similar fracture, but in this case the typical varus deformity (Fig. 4-A) developed. Shortening amounted to about one and one-half inches. A useful ankle was obtained by osteotomy after the epiphysis had ossified. (See Figure 4-B.)

There were two additional cases of deformity, which, however, do not belong to this series, as they were private cases of Dr. F. J. Cotton. These patients had medial fractures of the shaft and epiphysis into the joint (Fig. 5), and in each case varus deformity developed within a few months of the date of injury.

The fractures in these cases of deformity, we believe, were due to forced inversion. The cartilage plate is thus crushed between the bony epiphysis below and the shaft above. In our opinion, this crushing is the prime factor in the causation of deformity. The distal tibial epiphysis contributes considerably to the length of the leg, and, due to its location, it is subject to such forced inversion injuries. Deformity, due to fracture, is therefore more common here than in any other epiphysis. It may also be true that too early weight-bearing upon such an injured epiphysis is another factor.

CONCLUSIONS

1. In discussing the end results of epiphyseal fractures, each epiphysis must be considered individually.

2. The distal tibial epiphysis is subject to three types of fracture. In the first type, there is little or no damage to the cartilage, and deformity is consequently rare. In the second type, the cartilage is crushed in about 40 per cent. of the cases, with resulting deformity. In the third type, the cartilage is crushed and deformity is to be expected.

3. Malposition of the epiphysis, *per se*, is not a cause of deformity.

As we found in our study of the distal radial epiphysis, any displacement of the epiphysis is corrected by nature within a few months of the date of injury. We believe that in all cases the fracture should be reduced as accurately as possible. However, if complete reduction cannot be obtained, we believe it is wiser to allow Nature to further correct the displacement as she does than to subject these patients to osteotomy.

In summarizing our work on the epiphyses to date, we are convinced that deformity is due only to crushing of the epiphysis at the time of the injury or during osteotomy for correction. If an epiphysis has been so crushed, it is not humanly possible with our present knowledge to prevent the inevitable deformity. If the epiphysis has not been crushed, it will continue to grow normally, although alignment after repeated attempts at reduction may be poor.

REFERENCES

AITKEN, A. P.: The End Results of the Fractured Distal Radial Epiphysis. J. Bone and Joint Surg., XVII, 302, Apr. 1935.

Further Observations on the Fractured Distal Radial Epiphysis. J. Bone and Joint Surg., XVII, 922, Oct. 1935.

MCFARLAND, BRYAN: Personal communication.

Traumatic Arrest of Epiphysial Growth at the Lower End of the Tibia. British J. Surg., XIX, 78, 1931.

INDICATIONS FOR AND AGAINST THE LEG-LENGTHENING OPERATION

Use of the Tibial Bone Graft as a Factor in Preventing Delayed Union, Non-Union, or Late Fracture*

BY EDWARD L. COMPERE, M.D., CHICAGO, ILLINOIS

From the Department of Surgery, Division of Orthopaedic Surgery, University of Chicago Clinics

Inequality of leg length, resulting from shortening of one leg, is not necessarily sufficient indication for advising a lengthening operation. Shortening of not more than one and one-half inches may be compensated for by tilting the pelvis. If the shortening exceeds one and one-half inches, the surgeon must decide whether or not a better result can be obtained from lengthening the short leg or from shortening the well leg. The well leg may be shortened by one of two methods: resection of a segment of the femur, or the arrest of growth of one or more of the epiphyses of the normal extremity. The surgeon should keep in mind the fact that his responsibility is to equalize the length of the two legs. A major operation designed for the purpose of increasing the standing height of the patient should be condemned. Complications resulting from attempts to lengthen legs without recognition of some of the contra-indications have resulted in leaving some patients more crippled than before the operation. The following case reports illustrate some of these complications and the lessons which the author has learned from them.

FIG. 1

Case 1. W. K., male, aged seventeen years. Shortening of the right leg as a result of growth arrest from the proximal epiphysis of the right femur.

CASE 1. W. K., a male, aged seventeen years, was admitted to the hospital for treatment of inequality of leg length. The right leg was two and one-quarter inches shorter than the left. Growth arrest had followed epiphyseolysis of the capital epiphysis of the right femur at the age of twelve years. Operations had been performed to correct an adduction-flexion deformity of the hip and genu valgum of the knee. The standing height of the patient was five feet, ten and seven-eighths inches. (See Figure 1.) An osteotomy for lengthening the right femur was performed. Double skeletal traction was applied with the leg supported on a Braun frame, as described by Putti. The desired lengthening was obtained, but angulation of the fragments and malunion resulted. At the end of five months, a minimal amount of callus and ossification was present (Fig. 2). There was paralysis of the external popliteal nerve with toe-drop and anaesthesia over the dorsum of the foot.

Shortening of the well leg by resection of a segment of the left femur would have been a safer procedure. The patient refused to permit the shortening operation and, since the short leg was

*Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 14, 1936.

sound, strong, and free from any pyogenic infection, lengthening was thought to be a justifiable procedure.

Complications included delayed union and malunion. Angulation resulted from poor control of the fragments and inadequate splinting while traction was applied. The paralysis was due to stretching of the external peroneal nerve.

CASE 2. L. M., a female, aged fifteen years, was admitted to the Orthopaedic Hospital at the University of Chicago Clinics for lengthening of the left femur in January 1932. The standing height of the patient was five feet, one inch. Growth of the proximal epiphyses of the tibia and fibula had been arrested, following an attack of acute osteomyelitis, and the left leg was three and one-half inches shorter than the right (Fig. 4-A). The shaft of the femur had not been involved by the infection. An operation to lengthen the short femur was advised.

The periosteum of the femur was elevated for a distance of about seven inches. A Z-shaped osteotomy, six inches in length, was performed. During the operation one of the osteotomy fragments fractured and was tied to the shaft. Good alignment was maintained during the initial period of traction, but, after about two inches of lengthening had been obtained, there was separation of the fragments (Fig. 3). One month after the first operation, a full-thickness segment was removed from the right tibia and was placed as an onlay graft across the defect in the femur. Seventeen days after the second operation, the patient began to complain of pain over the upper portion of the healed wound. One month after the second operation, the temperature suddenly rose to 40 degrees centigrade, and the wound became swollen and red. Pus, from which hemolytic streptococci were cultured, was expressed when the wound was incised. Bone union occurred, but, during the year following this operation, a number of sequestra were removed. The patient now has a fibrous ankylosis of the knee with only a few degrees of motion. A sinus intermittently drains a few drops of purulent material. (See Figure 4-B.)

FIG. 2

Case 1. W. K. Roentgenogram showing poor union and malposition five months after the osteotomy.

Since this patient was a young woman with a total height of five feet, one inch, and since there had been multiple osteomyelitic foci, the operation of choice would have been that of shortening the right femur. Average standing height of a patient is far less important from the standpoints of function, gait, or appearance than is equality of leg length.

The complication of fracture of the osteotomy fragment could have been avoided by making drill holes along the line of osteotomy before inserting the chisel, and an oblique osteotomy would have created less weakness where the fragment joined the shaft. Periosteum was stripped

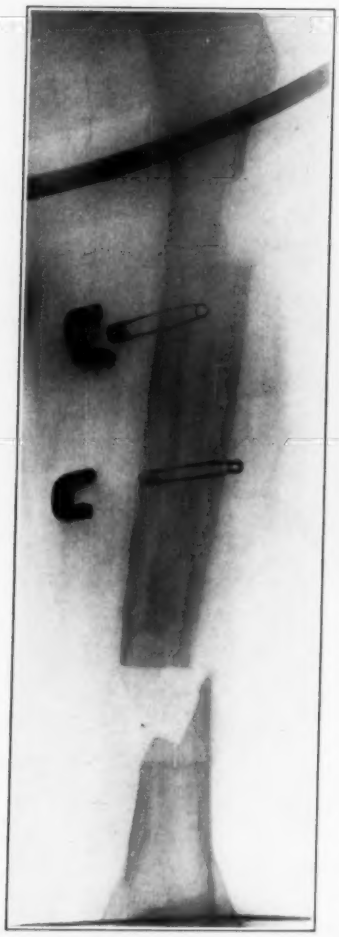


FIG. 3

Case 2. L. M., female, aged fifteen years. Roentgenogram showing fracture of the distal osteotomy fragment with more than one inch of separation.

FIG. 4-A

FIG. 4-B

Fig. 4-A: Case 2. L. M. Before operation, showing shortening of more than three inches. The scar above the knee represents the site of an osteotomy for correcting genu-varum deformity.

Fig. 4-B: Case 2. L. M. Two years after operation, showing that two inches of lengthening has been obtained. There is almost complete fibrous ankylosis of the knee. The patient still has more than one inch of shortening. Such a result does not justify the operation.

more widely than the author now considers advisable and this, together with further devascularization necessitated by a second operation one month later for insertion of the bone graft, led to aseptic necrosis, breaking down of the wound, and secondary infection.

CASE 3. J. K., a female, aged eighteen years, was admitted to the Orthopaedic Hospital of the University of Chicago Clinics, October 26, 1934. Ten years previously a pyarthrosis of the right hip and the right knee had resulted in ankylosis of the knee, deformity of the hip, and premature closure of the epiphyses of this bone. The right leg was three and one-half inches shorter than the left. The sinuses near the hip and the knee had been healed for from seven to eight years, and the shaft of the femur had at no time been grossly involved by the infection. The total standing height of the patient was four feet, eight inches. (See Figure 5.)

After the periosteum had been stripped for a distance of about ten inches over the middle and lower thirds of the short femur, a Z-type of osteotomy was done. A full-thickness tibial bone graft was obtained and attached to the lower fragment, so that it overlapped the osteotomy. One month after operation the roentgenogram showed a fracture of the distal fragment of the Z osteotomy with one-half inch of separation (Fig. 6-A). The tibial bone graft which had been applied did not overlap sufficiently to

FIG. 5

Case 3. J. K., female, aged eighteen years. Shortening of the right leg and ankylosis of the knee. Note multiple scars from healed sinuses both above and below the knee joint.

FIG. 6-A

FIG. 6-B

Fig. 6-A: Case 3. J. K. Roentgenogram showing the long Z-type of osteotomy, the distal fragment of which fractured after traction had been applied, with the resultant loss of continuity throughout a distance of almost one centimeter.

Fig. 6-B: Case 3. J. K. Roentgenogram showing grossly infected and deformed femur with non-union of the fracture at the site of the osteotomy.

bridge this defect. Traction was removed and the bone fragments were allowed to approach each other. Approximately eight weeks after operation, a sinus developed in the operative incision and frank pus was discharged. Drainage has continued and on two occasions sequestra have been removed. At the present time there is no bony union, although a moderate amount of involucrum has formed (Fig. 6-B). As a result of the removal of the traction following the fracture and the loss of bone from sequestration, the femur is shorter today than it was before leg-lengthening was attempted.

In retrospect, we are able to say definitely that this was not a suitable case for the leg-lengthening operation, since silent foci of pyogenic organisms are known to be retained in living bone for long periods of time. Errors in operative technique included: making an incision longer than was necessary for the lengthening desired, extensive stripping of periosteum throughout more than half of the length of the femur, use of the Z-type of osteotomy, and failure to attach the tibial bone graft so that it

Fig. 7-A

FIG. 7-B

Case 5. I. M., male, aged fourteen years. Roentgenograms taken five months and one year, respectively, after operation. They show an adequate amount of involucrum with firm bony union. The osteotomy fragments have retained their density and drill holes and saw-cut margins of the osteotomy fragments are clearly defined, indicating devitalization.

definitely overlapped the weakened zone. It is probable that aseptic necrosis occurred as a result of the devascularization of more than half of the shaft of the femur, and this led to sequestration and later suppuration. It would have been more advisable to have shortened the long leg, even though this reduced the standing height of the patient to less than four feet, six inches.

CASE 4. P. P., a male, aged seventeen years, entered the Orthopaedic Hospital at the University of Chicago Clinics, May 2, 1935, for lengthening of the right tibia and fibula. The right leg was three inches shorter than the left as a result of osteomyelitis which began in the right femur in 1927 when the patient was ten years of age. Growth arrest of both the distal and proximal epiphyses of the femur had occurred. In February 1932, the lower femoral and upper tibial and fibular epiphyses of the left leg were operated upon to arrest the growth. At the time of these epiphyseal arrests, the patient was fourteen years and five months of age and the difference of length of the legs was three inches. This operation prevented an increase in the shortening.

When the patient was brought into the hospital for the proposed lengthening of the tibia and the fibula of the right leg, his total standing height was five feet, four inches. An oblique osteotomy was performed in the right tibia and fibula—bones which had not been involved by the previous osteomyelitic infection and which roentgenographically were quite normal—and an onlay graft, removed from the left tibia, was attached across the defect. The patient stood the operation well, but there was an immediate rise of temperature which persisted. Suppuration developed, followed by septicaemia, gangrene, pulmonary embolism, and death.

The history of osteomyelitis in an extremity should preclude any plan to lengthen any bone of that extremity.

CASE 5. I. M., a male, aged fourteen years, sustained a fracture of the right femur at the age of seven years and this resulted in growth arrest of the distal femoral epiphysis. When admitted to the University of Chicago Clinics, he was fourteen years of age and

FIG. 8-A

Case 5. I. M. Sequestrated osteotomy fragments after excision. Note the sharply defined saw and drill cuts with some evidence of absorption at the extreme ends.

stood five feet, two inches in height. The right leg was two and one-quarter inches shorter than the left, and roentgenograms showed that longitudinal growth had been largely completed, since the epiphyses of both lower extremities were now fused to the metaphyses. The patient was psychologically disturbed because of his short stature, and surgical shortening of the well leg, which would reduce standing height to about five feet, was thought to be inadvisable.

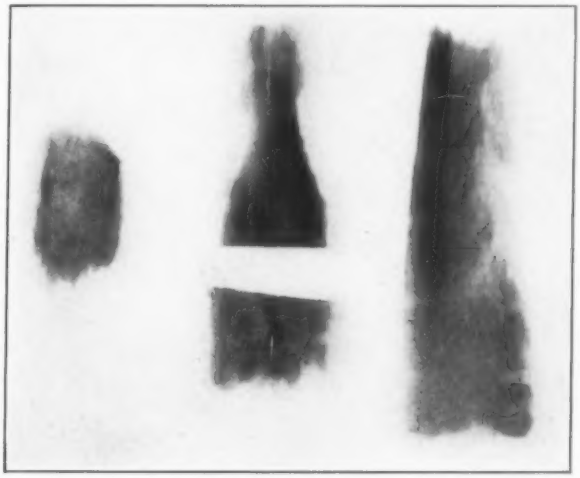


FIG. 8-B

Case 5. I. M. Roentgenogram of specimen showing density well preserved and the clear lines of the cut surfaces and drill holes.

On November 6, 1934, an operation was performed preparatory to lengthening the right femur. The periosteum was stripped from the femur for a distance of about ten inches. A long oblique osteotomy was performed. A tibial bone graft was tied to the proximal fragment. The wound healed *per primum*. Two and one-quarter inches of lengthening was obtained by means of the traction. On December 1, 1934, twenty-five days after

FIG. 9

Case 5. I. M. Roentgenogram of the femur thirteen months after successful lengthening of two inches and after excision of the sequestrated osteotomy ends. A small draining sinus still persists. The tibial bone graft *AB* was found to be viable throughout its length and firmly united, bridging the zone of lengthening.

the operation, the wound opened and purulent drainage followed. Union occurred, but subsequent roentgenograms (Figs 7-A and 7-B) showed gradual sequestration of the osteotomy fragments. Motion in the knee at the time of the removal of the cast was limited to about 10 degrees. On December 20, 1935, the sequestrated ends of the osteotomy fragments of the femur were removed (Figs. 8-A and 8-B). The tibial bone graft, however, was found to be viable and firmly united (Fig. 9).

DISCUSSION

A review of the reported cases of leg-lengthening operations shows that every surgeon who has attempted this formidable procedure has had some complications. Interest in the successful cases has sometimes detracted from the lessons that could be learned from the failures. No surgeon has attempted to list in detail the indications for or contra-indications to this operation and none has specifically emphasized the complications or failures which he has experienced. Complications in femur lengthening are more common than those which may occur when the tibia and fibula are lengthened.

In the series of femur lengthenings reported by Putti in 1921 and 1934, protocols of individual cases were omitted, but delayed union was the rule rather than the exception.

Abbott and Crego reported late fractures, angulation, and malunion of fragments and infection at the site of the pin insertions in some of their first eight cases of femur lengthening. In 1932 Abbott reviewed his entire series of forty-eight lengthenings of the tibia and fibula and twenty-five femur-lengthening operations. In seven of the twenty-five cases of femur lengthening there were late fractures. There were three cases of paralysis of the peroneal nerve, two of osteomyelitis at the osteotomy site following operation, and many less serious infections at the site of the insertion of the pin through an incision on the medial side of the thigh near the groin. Abbott stated in 1932: "In lengthening of the femur . . . we have experienced great difficulty in devising apparatus which will maintain alignment of the fragments."

Haboush and Finkelstein have quite frankly discussed their difficulties in lengthening the tibia and fibula. In their series reported in 1932 there were six cases of postoperative osteomyelitis, four of delayed union, and one case of non-union. Other complications included one deformity

of the foot, one fracture of the osteotomy fragment, and angulation in nearly all cases.

In 1935, in addition to describing similar complications in his series of forty-six leg-lengthening operations, Brockway stated that in a number of patients operated on during the growth years the lengthened leg was again one inch or more short at maturity.

The author has reported unsatisfactory results in five cases of leg lengthening and has emphasized complications. He has learned more from these cases than from those in which lengthening was obtained with less difficulty or with fewer complications.

The following complications have been encountered in cases in which leg-lengthening operations have been performed:

1. Stretch paralysis of the sciatic or the external popliteal nerve.
2. Increased weakness of lengthened muscles in old cases of poliomyelitis.
3. Fracture of the osteotomy fragment.
4. Malunion.
5. Delayed union or non-union.
6. Osteomyelitis from wound infection or lighting up of a silent bacterial focus.
7. Traumatic arthritis and limitation of motion in the knee.
8. Late fracture.
9. Pressure or stretch necrosis of the skin in the zone of lengthening.
10. Necrosis of bone due to excessive subperiosteal stripping. This may increase the likelihood of infection.
11. Malposition of the foot due to rotation following lengthening.
12. Circulatory disturbance with prolonged oedema in the lengthened limb.
13. Displacement of the head or of the distal end of the fibula when this bone is not lengthened as much as is the tibia.
14. Protrusion of the osteotomy fragment of the tibia through the skin.

Hey Groves has continued to advocate leg shortening as the operation of choice for many types of cases of inequality of leg length. He says: "The short leg in these cases (healed tuberculosis of the hip or infantile paralysis) is nearly always undernourished, with poor blood supply, weak muscles, and slender bones. . . . As the limb is therefore ill adapted to plastic operations, it is much wiser, in my opinion, to shorten the sound leg rather than attempt to lengthen the weak one."

The normal femur may be safely shortened by 25 per cent. of its total length. Hey Groves has added: "It is very remarkable how the slack of four inches of muscle is taken up within a few months and the full muscular power of the leg regained."

Camera has used this operation twenty-one times in children with good results.

An analysis of the author's cases and of those reported by others

enables him to list the following conditions which would cause him to advise against leg lengthening and to advocate shortening of the well leg if the discrepancy in leg length is great enough to justify operation. Contra-indications to leg lengthening are as follows:

1. Shortening of less than three centimeters.
2. Age of patient under fifteen or sixteen years.
3. Any patient who is sufficiently tall to permit shortening the longer leg or who will not be psychologically disturbed because of loss in standing height by:
   a. Epiphyseal growth arrest, or
   b. Resection of a segment of the femur of the long extremity.
4. Weak or paralyzed muscles of the hip or knee.
5. Shortening so marked that maximum lengthening will not sufficiently equalize the extremities to enable discarding of shoe elevation or other appliance.
6. History or clinical and roentgenographic evidence of previous osteomyelitis in the short leg, or other pathology in the bone to be lengthened,—*i.e.*, fibrocystic disease.
7. Congenital short leg, as in absence of part of the bone to be lengthened, or other severe deformities in which an artificial limb may give a better functional result.

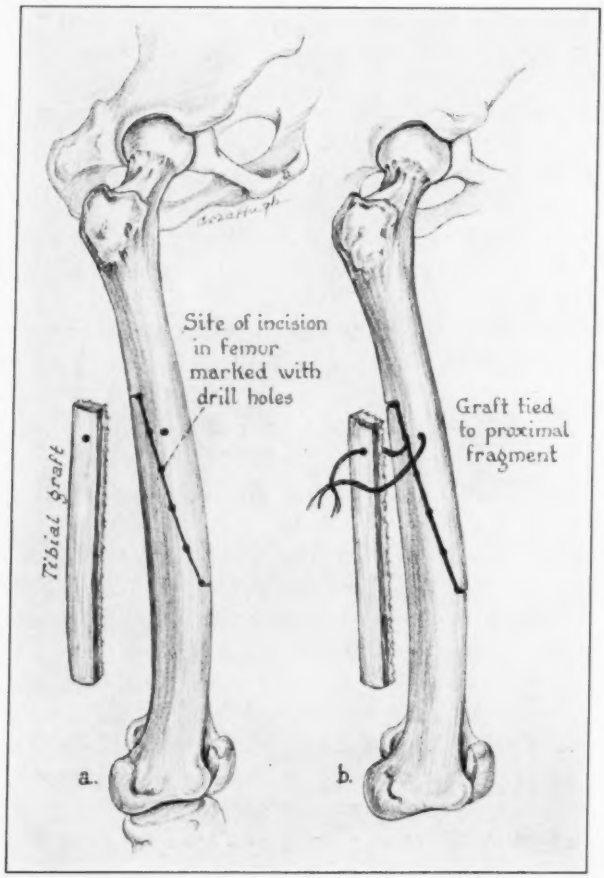


FIG. 10-A

Diagrammatic illustration of the type of osteotomy which the author's experience has led him to adopt, showing the tibial bone graft being applied.

Phemister has demonstrated that inequality of leg length in the growing boy or girl may, in suitable cases, be corrected by the surgical fusion of the lower femoral epiphysis, the upper or lower tibial and fibular epiphyses, or a

combination of two or all three of these epiphyses, to their respective metaphyses.

This is a simple operative procedure and entails little risk to life or limb. In the University of Chicago Clinics more than 100 epiphyseal-arrest operations have been performed on seventy patients without any complications and with preservation of complete and normal function in the well leg subjected to this operation. In no instance has growth of the well leg been inhibited so much that the originally short leg became the longer of the two.

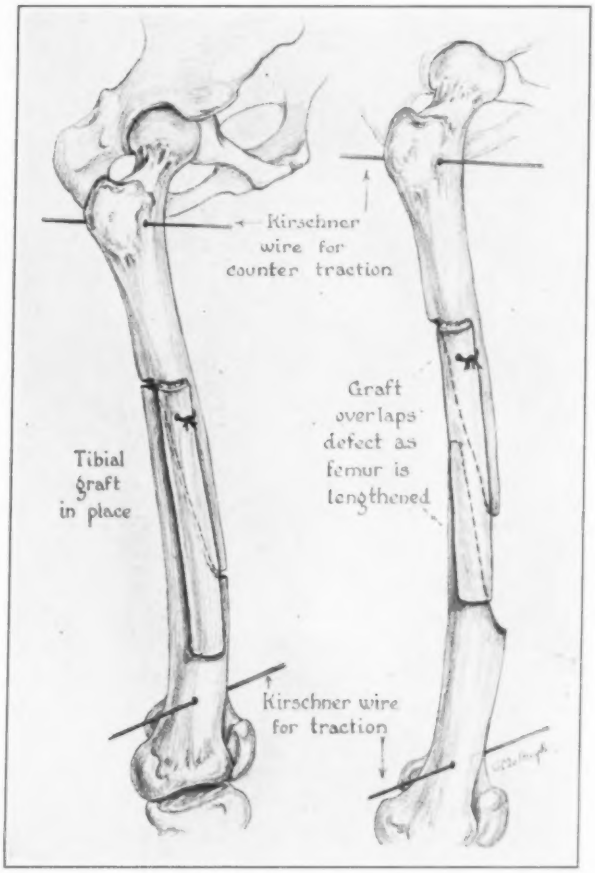

Kirschner wire for counter traction
Graft overlaps defect as femur is lengthened
Tibial graft in place
Kirschner wire for traction

FIG. 10-B

Tibial bone in place as an onlay graft, both before and after lengthening has been obtained, illustrating the splinting effect and advantage in obtaining more rapid and stronger bone union.

Harris has reported that excision of the lumbar sympathetic rami and ganglia on the side of the paralysis may stimulate growth in the short limb. Bisgard found no increase in length growth of an extremity following lumbar sympathectomy on young goats and monkeys. Arrest of epiphyseal growth by means of roentgen irradiation has been successfully accomplished in experimental animals, but the procedure is not yet considered to be well enough standardized to be recommended for young children.

Although complications of the leg-lengthening operation have been common and the author has enumerated a number of contra-indications, there are selected cases in which he recommends the operation and considers that the risk to life or limb may be justified. Indications for leg lengthening are as follows:

1. Shortening of more than one inch that produces impairment of gait.

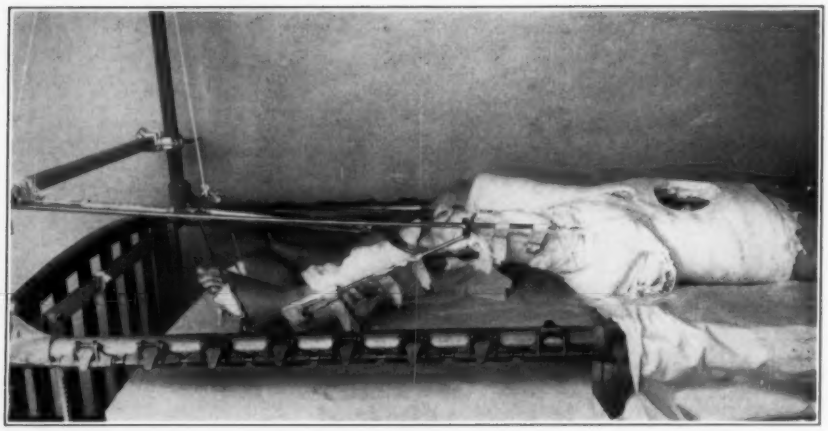


FIG. 11

Illustrating the method of applying the modification of the Hoke type of skeletal traction which, in the author's experience, has afforded satisfactory control of the fragments.

2. Young adult or adolescent patient.

3. Good to normal muscle power at hip and knee and a stable foot, or one that can be stabilized surgically.

4. Absence of previous infection of bones of the short extremity.

5. Refusal of patient to permit, or other contra-indication to, shortening of the longer leg.

The lessons learned by the author from the errors in judgment or technique which led to the complications described in the preceding report of five cases of leg lengthening have enabled him to adopt a plan of operation which includes safeguards and principles that may be of some help to others.

The methods of operative lengthening of the tibia and the fibula have been standardized by Abbott and Crego, Haboush and Finkelstein, and Moore and successfully applied with slight modifications of apparatus or technique by many other surgeons throughout the world.

THE TIBIAL-BONE-GRAFT TECHNIQUE OF FEMUR-LENGTHENING OPERATION

Lengthening of the femur has usually been performed by some modification of the oblique osteotomy of the midshaft, followed by skeletal traction as described by Putti in 1921. Putti's patients were unable to bear weight on the limb which had been operated upon until nine to fifteen months after operation. The writer's experience with leg lengthening has resulted in the adoption of the following plan of operation:

1. A Kirschner wire or Steinmann pin is inserted anteroposteriorly through the trochanter.

2. An elastic bandage is applied from toes to groin to drive the blood from the limb.

3. An Esmarch bandage is then applied above the pin as a tourni-

quet and the elastic bandage is removed from the leg. The thigh is prepared with iodine and draped.

4. A posterolateral incision is made and the femur is exposed by separating the muscles from the lateral fascial septum.

5. The periosteum is stripped only as far as the length of the osteotomy, to avoid devascularizing the bone.

6. An oblique rather than a Z-type of osteotomy is used, as there is less danger of fracture. This cut may be made through the outer cortex with the motor saw.

7. The osteotomy should be only about two inches longer than the desired lengthening.

8. Holes, one eighth of an inch in diameter, are drilled at intervals of one centimeter through the medial cortex in the line of osteotomy.

9. A metal pin or wire is inserted through the femur above the condyles.

10. A tibial onlay bone graft is next added to splint the osteotomy site and to aid in union. (See Figures 10-A and 10-B.)

11. A cast is applied which includes the body and opposite leg

FIG. 12

Case 6. R. B., male, aged seventeen years. Roentgenogram of femur after lengthening of approximately two and three-quarters inches. Correction of adduction-flexion deformity at the site of osteotomy. The tibial bone graft *AB* has united firmly, reenforcing the zone of union.

FIG. 13

Case 6. R. B. Roentgenogram after lengthening the tibia with the Moore modification of the Abbott apparatus, showing the satisfactory alignment of the fragments. The tibial bone graft *AB* is seen in position on the lateral surface, reenforcing the zone of lengthening.

FIG. 14-A

FIG. 14-B

Fig. 14-A: Case 6. R. B. At time of first admission, showing marked shortening both above and below the knee.

Fig. 14-B: Case 6. R. B. After lengthening the femur, tibia, and fibula a total of more than five inches and correction of the adduction-flexion deformity through the osteotomy, there is a functional increased length of six inches. Because of a slight flexion deformity at the knee, a raise of one centimeter is now worn on the heel of the shoe.

and which extends downward onto the upper third of the thigh of the short extremity, in which portion the proximal wire or pin is incorporated. This pin and cast immobilize the proximal fragment and reduce the variables in maintaining accurate alignment. The ring of the rigid Thomas splint is firmly attached to the cast and the lower pin to the splint by means of the turnbuckle. This affords control over the lower fragment. (See Figure 11.)

The following case illustrates the successful application of the described technique in lengthening both the tibia and the femur.

CASE 6. R. B., a male, aged seventeen years, came to the University of Chicago Clinics on April 28, 1934, because of shortening of the left lower extremity amounting to fourteen and five-tenths centimeters. Tuberculosis of the left hip had been diagnosed at the age of four years. The patient had been treated by intermittent immobilization in plaster casts over a period of seven years. Since the age of eleven, there had been no flare-up in the hip. As the patient grew older it had been necessary to increase the raise on the shoe to approximately six and one-quarter inches.

Examination revealed marked atrophy and shortening of the left lower extremity (Fig. 14-A). The hip was held in a position of adduction and flexion, with only a few degrees of motion. More than two and one-half inches of the shortening was in the lower leg, the result of atrophy from long immobilization. The patient's total standing height was five feet, seven and two-tenths inches. He was acutely aware of his short stature and would have preferred amputation to reduction of his standing height by a leg-shortening operation.

On June 27, 1934, an oblique osteotomy, approximately five inches in length, was made in the left femur by the technique described. A tibial graft, one centimeter in width and twelve centimeters in length, was now tied to the proximal fragment of the osteotomized femur, so that it extended beyond the osteotomy incision. The leg was lengthened two and three-quarters inches by the application of turnbuckle traction over a period of three weeks. The wound healed *per primum* and, by correcting the adduction-flexion deformity by abducting and extending the leg at the site of the osteotomy, a total functional increase in length of more than three inches was obtained. Roentgenograms showed evidence of callus two months after the operation, and two weeks later the patient was discharged in a cast, walking with crutches. Four months and one week after operation all cast immobilization was discontinued and the patient was allowed to begin weight-bearing. There was no loss of function of the peroneal or sciatic nerve. (See Figure 12.)

Eight and one-half months after the oblique osteotomy of the femur, a lengthening operation was performed on the left tibia and fibula. A bone graft from the right tibia was attached to the proximal fragment in such a manner that it overlapped the osteotomy. The lengthening apparatus used was the Moore modification of that described by Abbott. Two and one-half inches of lengthening was obtained. (See Figure 13.) Six weeks after operation a roentgenogram showed callus and union of fragments and of the graft. A small area of necrosis of the edges of the skin in the midportion of the wound developed, but there was no suppuration.

The patient was discharged from the hospital on May 16, 1935, ten weeks after operation. There was temporary diminished sensory response over the dorsum of the foot and toe-drop. Both sensation and motor function have been recovered. A one-centimeter raise is necessary to equalize the leg length functionally. (See Figure 14-B.)

SUMMARY

In the opinion of the author the operation of choice for equalizing leg length in the majority of cases is that of shortening the longer leg by: (1) resection of a portion of the longer femur; (2) arrest of growth by fusing to the shaft one or more of the epiphyses of the longer limb.

When leg lengthening is definitely indicated the author recommends the use of a tibial onlay bone graft to bridge the zone of lengthening of either the femur or the tibia as a factor of safety in preventing delayed union, non-union, or late fracture.

REFERENCES

ABBOTT, L. C.: The Operative Lengthening of the Tibia and Fibula. J. Bone and Joint Surg., IX, 128, Jan. 1927.

Lengthening of the Lower Extremities. California and West. Med., XXXVI, 6, 1932.

ABBOTT, L. C., AND CREGO, C. H.: The Operative Lengthening of the Femur. Southern Med. J., XXI, 823, 1928.

BISGARD, J. D.: Longitudinal Bone Growth. The Influence of Sympathetic Deinnervation. Ann. Surg., XCVII, 374, 1933.

BROCKWAY, A.: Clinical Résumé of Forty-Six Leg-Lengthening Operations. J. Bone and Joint Surg., XVII, 969, Oct. 1935.

CAMERA, U.: L'Accorciamento a scopo ortopedico dell' arto sano nei postumi della coxite. Boll. e. Mem. Soc. Piemontese di Chir., II, 223, 1932.

GROVES, E. W. HEY: An Address on Stature and Pose. The Problem of Unequal Legs. British Med. J., II, 1, 1931.

HABOUSH, E. J., AND FINKELSTEIN, HARRY: Leg Lengthening with New Stabilizing Apparatus. J. Bone and Joint Surg., XIV, 807, Oct. 1932.

HARRIS, R. I.: The Effect of Lumbar Sympathectomy on the Growth of Legs Shortened from Anterior Poliomyelitis. A Preliminary Report. J. Bone and Joint Surg., XII, 859, Oct. 1930.

HARRIS, R. I., AND MCDONALD, J. L.: The Effect of Lumbar Sympathectomy upon the Growth of Legs Paralyzed by Anterior Poliomyelitis. J. Bone and Joint Surg., XVIII, 35, Jan. 1936.

MOORE, B. H.: A Bone Lengthening Apparatus. J. Bone and Joint Surg., XIII, 170, Jan. 1931.

PHEMISTER, D. B.: Operative Arrestment of Longitudinal Growth of Bones in the Treatment of Deformities. J. Bone and Joint Surg., XV, 1, Jan. 1933.

PUTTI, VITTORIO: The Operative Lengthening of the Femur. J. Am. Med. Assn., LXXVII, 934, 1921.

Operative Lengthening of the Femur. Surg. Gynec. Obstet., LXVIII, 318, 1934.

SACRARTHROGENETIC TELALGIA

III. A Study of Alternating Scoliosis

BY HORACE C. PITKIN, M.D., AND HOMER C. PHEASANT, B.S., A.B.,
SAN FRANCISCO, CALIFORNIA

This article is the third of a series of five*. It is based upon additional statistical analyses of the 506 records used in the first article, and it presents a detailed review of one of these records. Its scope is limited to a study of the so called "alternating sciatic scoliosis", and its purpose is to describe the mechanism of the so called "sacro-iliac slips".

In reviewing the literature we have found mention of twenty-two cases of alternating sciatic scoliosis, the first of which was described by Remak in 1891. (See Table I.) The name given to these cases refers to the presence of the following characteristic findings:

1. Telalgia in the buttocks, in the lower extremities, or in both locations.

2. Scoliosis of the type described by Steindler as "decompensated",—that is, showing a marked lateral deviation (list) of the trunk as a whole.

3. Alternation (variation in the direction) of the list that does not require voluntary effort for its maintenance after the change has occurred.

Certain additional characteristics are worthy of mention:

1. Alternation of the list is most spectacular when it is produced by some type of active manipulation, but it may occur spontaneously, or as the result of passive manipulation.

2. In those cases in which alternation can be reproduced at will, the change typically is sudden and painful, and is accompanied by a springlike snap that may be audible and palpable.

3. The subject cannot maintain the vertical position of the spine, but slips into one of the two lists.

4. Of the two lists, one usually is more stable than the other; that is, one list tends to be assumable only by manipulation, but it may revert spontaneously.

5. There usually is little difference in the degree of discomfort after the change has occurred.

6. The photographs of Calissano's patient showed essentially perfect mirror-images (that is, reversal) of the spinal curvature and rotation in the two lists, but the roentgenograms were not reproduced. No other illustrated case was symmetrical.

7. None of the observers was able to explain the mechanism of alternation, although Léri stated definitely that in his two cases the snapping sound had an osteo-articular origin.

* Of the other four articles, two have been published under the same title [18]; the remaining two are now in preparation and deal with the following phases of the subject:
IV. Diagnosis;
V. Treatment.

TABLE I

REPORTED CASES OF ALTERNATING SCIATIC SCOLIOSIS

No. of Cases	Reported by	Year
1	Remak	1891*
1	Higier	1895*
1	Mayer, O.	1895*
3	Phulpin	1895*
1	Vulpius	1896*
1	Ehret	1899*
1	Fopp	1899*
1	Lord	1913
2	Léri	1919
1	Blencke	1920*
1	Ducamp and Carrieu	1920
1	Calissano	1924
1	Stein	1924*
1	Mayer and Testu	1926
1	Dainelli	1927
3	Capener	1933
1	Fairbank	1933
Total 22 Cases		

* Cases found by Calissano.

From the fact that we could find mention of only twenty-two cases in a period of forty-five years, it appears that alternating scoliosis is a rare condition, but this is not true. Actually, only the more spectacular cases have been reported. We have found alternating scoliosis in sixty-eight, or 13.4 per cent., of our 506 cases. The change occurred in thirty-six instances as the result of passive manipulation; in twenty-two, its occurrence was spontaneous; in ten, the change was produced by active manipulation. In six of these ten instances the alternation could be reproduced at will, but mirror-images were present in only one case. This case, the detailed description of which follows, stimulated us to undertake the investigation that we are reporting in this series of articles.

CASE REPORT

N. McI., a mechanic and truck-driver, thirty-four years of age, came to us on January 30, 1929, because of "sciatica" that had affected the right lower extremity for two months.

Past History

In February 1927, the patient had suffered an injury to the right sacro-iliac joint. He was standing, bending forward about 45 degrees at the hips, with the left leg advanced, and with most of his weight supported by the right leg which was semiflexed at the knee and hip. He was lifting strongly against the handle of a large wrench, when the wrench slipped. The patient suffered immediate, lancinating pain in the right gluteal region and at once there developed a list of the trunk to the left, but he continued to work for the rest of the day (two hours). On the following morning, the patient was unable to leave his bed, because of pain in the lower back and right buttock. He returned to work on the

second day and worked steadily, although the pain and list persisted for almost two months. The list was sufficiently noticeable to cause many jests among the patient's fellow workmen, but the pain never extended to the thigh or leg.

Present Illness

Early in December 1928, the patient began to notice a gradual return of the left list. The telalgia in the right buttock also returned, but at this time it spread to the right posterior thigh and calf, with an occasional appearance in the right groin. In the latter part of December 1928, the patient was obliged to stop working, because of the increasing severity of the pain. In the latter part of January 1929, he discovered that he could alternate the list.

Condition on Admission

The patient slept poorly, and frequently was awakened by pain. He was obliged to sleep on his left side or, for short periods, on his back. The pain was greatly aggravated by prone recumbency, or by right lateral recumbency, and it was impossible for him to sleep in these positions. To turn from supine recumbency onto the left side was difficult and painful, but turning from the left side to the back, or even to the right side, was easy and painless. The patient could ease the pain at times by rubbing or beating against the right buttock with the heel of his hand, but he noted that pressure immediately below the posterior-superior spine of the right ilium often caused telalgia in the posterior thigh and calf. In the morning, the patient could not bend over the basin to wash his face, and he had great difficulty in walking, because of pain in the right buttock and calf "like a muscle cramping". By evening, he could walk without pain, unless he took too long a stride or made a misstep. A long, fast, or uphill walk always caused cramplike telalgia in the right calf and right groin. Coughing, sneezing, bending, lifting, prolonged sitting, and riding in automobiles all aggravated the pain; local heat and diathermy seemed to relieve it. Changes in the weather had no effect upon the degree of discomfort.

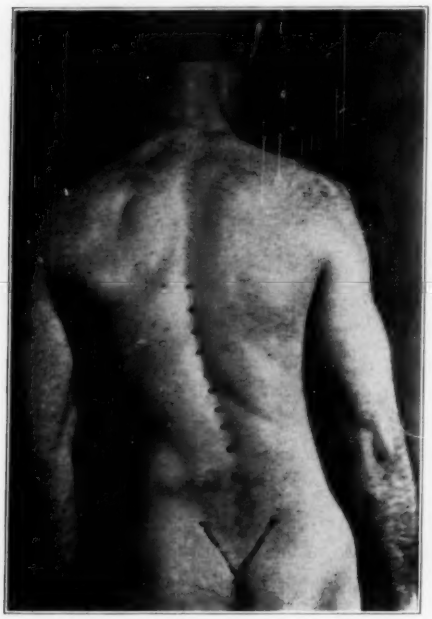


FIG. 1

Alternating scoliosis: left list. Note the position of the sacrum.

FIG. 2

Alternating scoliosis: right list. Note the position of the sacrum.

A left list (Fig. 1) was present at all times, except when the patient voluntarily shifted to the right. The patient had discovered that "something would suddenly slip", if he pressed downward upon the hips with his hands and simultaneously bent his trunk toward the right (Fig. 3). He located this "something" at the posterior-superior spine of the right ilium and stated that the "slip" often was palpable and audible as a "low-pitched pop". Just before the occurrence of the slip, the muscles of the back "seemed to set themselves in preparation" for it, and, as the slip occurred, an excruciating pain ran from the posterior-superior spine of the right ilium downward through the buttock, the posterior and lateral thigh, the calf, and the heel. There was no pain in the foot, but at times there was "an electric tingling" over the dorsal and lateral aspects of the foot and in all of the toes. After the slip had occurred the pain promptly disappeared, the patient was comfortable again, and the trunk was listed toward the right (Fig. 2).

The patient habitually used the left list, because he never shifted involuntarily from the left to the right, whereas any misstep or sudden turn would cause him to shift involuntarily from the right to the left. These involuntary slips always caused the patient's trunk to flex, as it shifted from right to left. By reversing the manoeuver that produced the right list, the patient could produce the left list without flexing the trunk. As the slip occurred, an excruciating pain ran from the right heel upward through the calf, occasionally into the posterior thigh, more rarely into the groin, but never into the buttock.

The patient was intelligent, cooperative, mechanically-minded, and an accurate observer. There were no symptoms of neurosis or of coincidental strain in other joints, and no complications caused by compensation, insurance, or legal tangles.

Physical Examination

The general examination showed that the patient was a healthy, well-developed, and well-nourished individual of the "normal" anatomical type. The local examination, with the patient in the erect position, resolved itself into the examination of three different individuals: the first, listed to the left (Fig. 1); the second, listed to the right (Fig. 2); and the third, in the act of changing the direction of the list (Fig. 3).

Left List: There was obvious spasm of both sacrospinalis muscles, which was more marked on the left. The left shoulder was carried lower than the right. The shoulder girdle and upper chest were rotated toward the left about the long axis of the trunk. The pelvis, as a whole, was rotated toward the right about the long axis of the trunk. The spine showed a lateral scoliosis which was convex on the left in the dorsal region and convex on the right in the lumbar region. The pelvis, as a whole, was shifted laterally toward the right for a distance of one and one-half inches. The right gluteal crease was one inch lower than the left. The normal lumbar lordosis was increased. The left posterior-superior iliac spine was lower than the right, and a line connecting the two deviated 7 degrees from the plane of the horizon. The left lower extremity was held in a position of 10 degrees of internal rotation. Palpation revealed tenderness of both posterior sacro-iliac ligaments on the right side.

FIG. 3

Alternating scoliosis: shifting. The change from the left to the right list has taken place, but the secondary dorsal curve and rotation have not made their appearance.

Tenderness was most acute just below the right posterior-superior iliac spine. Forward bending to 30 degrees was painless, but at this point the patient began to flex the right knee and to complain of pain in the right gluteal region. Continued forward bending caused the pain to radiate downward, first into the posterior and lateral thigh, and then into the calf. The patient would not bend beyond 45 degrees. Backward bending was normally performed to 35 degrees without pain. The angle of inclination of the right ilium was increased and measured 20 degrees*.

Right List: The patient showed a mirror-image (*i.e.*, a reversal) of the following items that we mentioned in our description of the left list: the spasm of the sacrospinalis muscles, the level of the shoulders, the rotation of the shoulder girdle and of the pelvis as a whole, the lateral spinal scoliosis, the lateral shift of the pelvis, and the level of the gluteal creases. The normal lumbar lordosis was decreased. The right posterior-superior iliac spine was lower than the left, but a line connecting the two deviated only 2 degrees from the plane of the horizon. The internal rotation of the left lower extremity disappeared. Palpation revealed tenderness of both posterior sacro-ischial ligaments on the right side, but the tenderness of the sacro-iliac ligaments disappeared. Tenderness was most acute over the free medial edge of the sacrotuberous ligament, just above the ischial tuberosity. Forward bending to 45 degrees was painless; at this point the patient complained of cramplike pain in the right calf, but he did not attempt to flex the right knee. Continued forward bending caused the pain to radiate upward into the posterior thigh, but not into the buttock, and the patient would not bend beyond 55 degrees. Backward bending, to an angle of not more than 10 degrees, caused a sudden pain in the right anterior thigh,—a type of telalgia that the patient had not experienced previously. This was so severe that the patient suddenly and involuntarily flexed his spine, shifted back into the left list, and thereafter was unwilling to repeat the manoeuver. The angle of inclination of the right ilium was decreased and measured 5 degrees.

Shifting from Left to Right: The patient placed his hands upon his hips and slowly forced the trunk toward the vertical position (right), at the same time forcing the pelvis toward the left. The rotation of the shoulder girdle and of the pelvis about the long axis of the trunk disappeared. As the upper spine reached the midline, the entire musculature of the back became boardlike in its rigidity; the right sacro-ischial ligaments became exquisitely tender; and the patient complained of pain in the right buttock and posterolateral thigh. As suddenly as when a spring is released, and just as the upper spine passed the midline, the curve of the lumbar spine was reversed, and the lumbar lordosis was decreased. Simultaneously, a deep, hollow pop was produced, the maximum intensity of which we located by palpation and by auscultation at the right posterior-superior iliac spine, and the patient complained momentarily of an exquisite pain that radiated from the right buttock and thigh to the calf and heel. The rotations of the shoulder girdle and of the pelvis, the lateral shift of the pelvis, and the inequality in the tension of the sacrospinalis muscles, all appeared in their new forms as the pressure of the hands was released and as the trunk settled down into the right list.

Shifting from Right to Left: When voluntarily produced, this shift was an exact reversal of the shift from left to right. Just as the upper spine reached the midline, the posterior sacro-iliac ligaments became exquisitely tender, and the patient complained of pain in the right calf. Just as the popping sound occurred, the patient complained momentarily of an exquisite pain that radiated from the right calf upward into the posterior thigh and occasionally into the right groin.

Sitting: The patient could bend the trunk to the right or to the left without any slip or pain, but the left-dorsal-right-lumbar scoliosis remained. He could bend forward 60 degrees without pain until his chest touched his thighs. The left knee could be extended actively to 180 degrees without pain, but even the effort involved in starting to extend the right leg caused pain in the right buttock. This pain radiated down the right posterior thigh and calf, if extension was continued, and limited extension to 135 degrees.

* This was the first case in which we measured the angle of inclination, and there is no record of the inclination of the left ilium.

Prone Recumbency: In this position, the muscle spasm, the list, and the spinal curvature disappeared. Any motion caused spasm of the muscles to reappear. If the patient rose to the knee-chest or knee-hand position, the left-dorsal-right-lumbar scoliosis reappeared. Tenderness of the posterior sacro-iliac ligaments remained. In left prone-knee flexion [17], the heel came to within six inches of the sacrococcygeal junction before the buttock began to rise (Ely's sign), but in right prone-knee flexion, the buttock began to rise at nine inches, and the patient complained of pain in the right gluteal region.

Right Lateral Recumbency: The patient could not maintain this position long enough for examination, because it produced telalgia in the right buttock, posterior thigh, and calf.

Left Lateral Recumbency: Compression of the iliac crests did not produce telalgia. Gaenslen's sign (acute flexion of the left hip to fix the pelvis, and passive extension of the right hip) produced pain in the right buttock while the right hip still remained in a position of 10 degrees of flexion.

Supine Recumbency: In combined hip-and-knee flexion, the patient could bring both thighs against the chest without pain. Passive straight-leg raising was stopped on the left at 85 degrees by tension of the hamstring tendons, but it was stopped on the right at 22 degrees by pain in the right buttock, and any attempt to carry the leg higher caused telalgia in the posterior thigh and calf. Both lower extremities were equal in length and in circumference. The cremasteric reflex, the patellar reflex, and the Achilles-tendon reflex were all slightly diminished on the right.

Roentgenographic Examination

In the supine position, the spine was straight, there were no arthritic changes, and no noteworthy congenital anomalies. Teleoroentgenograms of the spine in the two lists (Fig. 4) showed the "structural" [2] type of scoliosis that we have described in the physical examination. Similar roentgenograms of the pelvis (Fig. 5) showed lateral bending of the sacrum toward the right in the left list, and toward the left in the right list.

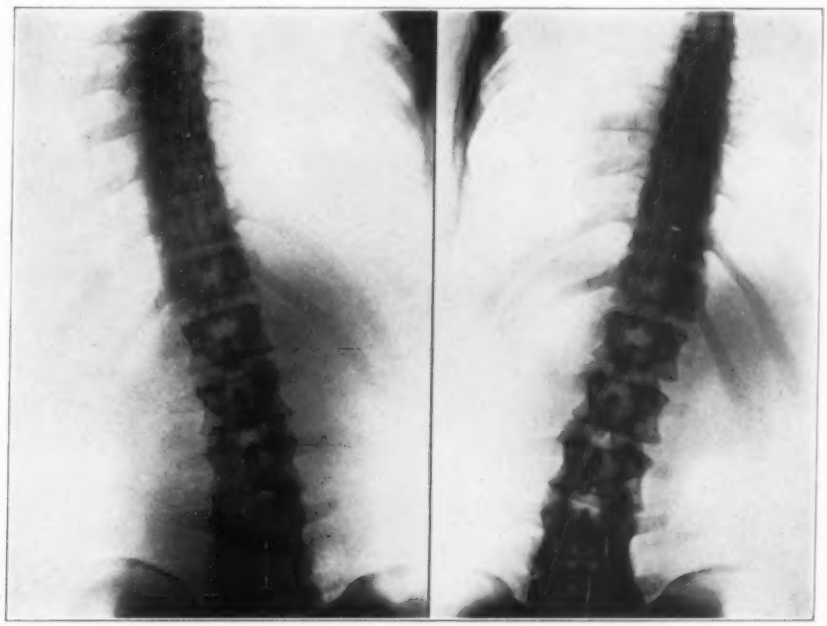


FIG. 4

Alternating scoliosis. Teleoroentgenograms of the spine, taken with the subject in the standing position and viewed from behind.

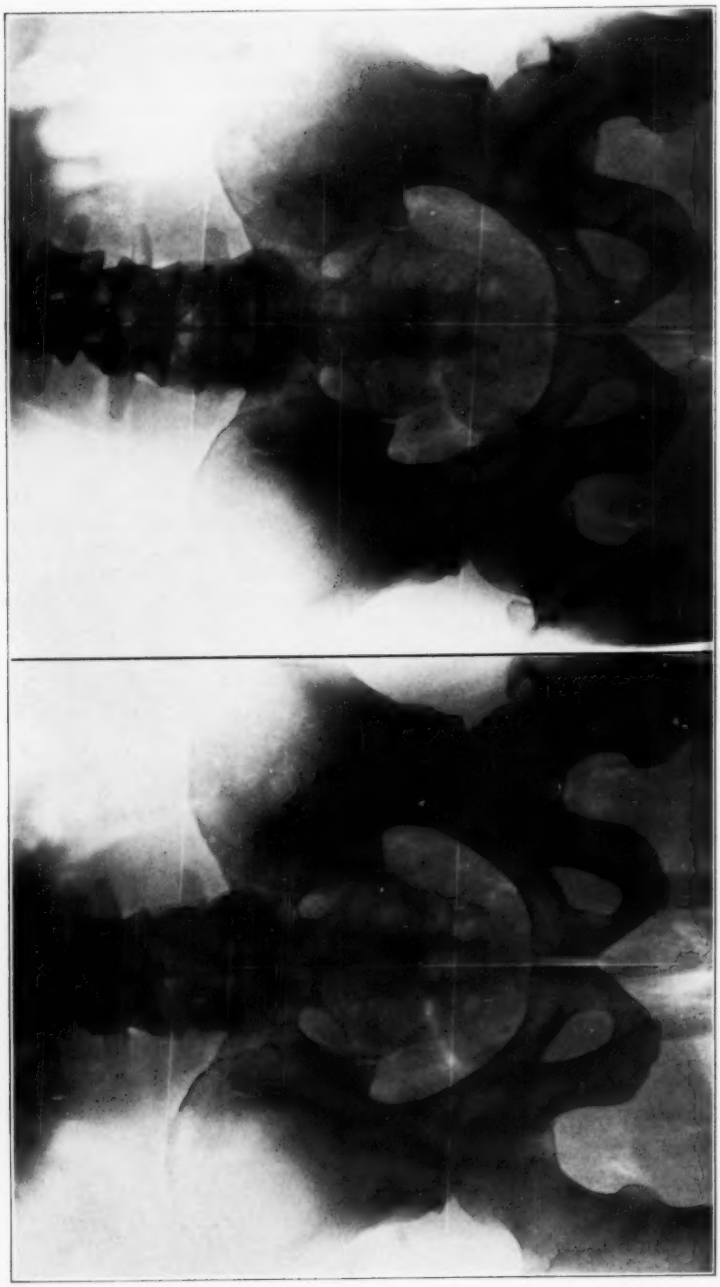


FIG. 5

Alternating scoliosis. Teleoroentgenograms of the pelvis, taken with the subject in the standing position and viewed from behind. (The apparent inequality in the length of the lower extremities is due to the error of the photographer who used the line drawn through the middle of the sacrum as a vertical in placing the films for reproduction.)

In this case, the patient's unequivocal localization of the "something" that slipped, the adventitious sounds of osteo-arthritic origin, the type of the telalgia, the ligamentous tenderness, and the usual tests by which we were accustomed to diagnose sacro-iliac dysfunction, all directed us to the right sacro-iliac joint as the cause of the alternating scoliosis. Still, one might consider this joint to have been more sinned against than sinning, if it were not for the following facts:

1. The reactions of the presacral vertebral column were the usual ones that are found when the internal balance is disturbed (as by an hemivertebra) or when the external support is deranged (as by paralysis or contracture of muscles). No such bony or muscular abnormality could be demonstrated.

2. Lateral bending in the standing position caused alternation of the scoliosis; lateral bending in the sitting position did not. Since the actions of the intrinsic spinal muscles are not altered in these two positions, the pelvic musculature must have been of paramount importance in the production of alternation.

3. Pathological mobility of the sacrum was demonstrated in the roentgenograms (Fig. 5). In the left list, in which the inclination of the right ilium was sharply increased, the right side of the sacrum did not follow the ilium upward and forward, as it should have done normally*. The roentgenogram shows very clearly that the right side of the sacrum has moved downward (and backward), so that a line drawn through the center of the sacrum falls to the left of the symphysis pubis. Thus, the foundation of the spine is deviated (and rotated) toward the right. Similarly, in the right list, in which the inclination of the right ilium was sharply decreased, the right side of the sacrum moved upward (and forward), again reversing the direction of normal movement.

4. The left list was more stable than the right list, just as the sacrum is more stable in flexion than in extension, because the sacrum had slipped downward and backward into the iliac mortise. Any unguarded movement tended to unlock the sacrum in the unstable right list (upward and forward slip), and gravity promptly returned it to the stable position.

5. The stable left list persisted in the standing, sitting, knee-hand and knee-chest positions. Therefore, the fixed position of the sacrum in the stable slip did not depend upon the action of the pelvic musculature which was so important in the production and maintenance of the unstable slip.

* In the second article of this series we showed that the sacrum normally exhibits two types of motion:

1. Flexion and extension about the transverse axis of the sacrum. In flexion, the sacrum glides downward and backward upon the ilia. Since the iliac mortise is constricted inferiorly and posteriorly, the sacrum is more firmly wedged between the ilia and is more stable in flexion than in extension.

2. Lateral bending and rotation. These two motions never are encountered separately. They are caused by antagonistic movements of the ilia about the transverse axis of the symphysis pubis. When an ilium decreases its angle of inclination, the contiguous sacral surface moves downward and backward. When an ilium increases its angle of inclination, the contiguous sacral surface moves upward and forward.

6. The right gluteal fold was lowered (gluteal relaxation) in the stable left list and was elevated (gluteal contraction) in the unstable right list. The contraction of the gluteus maximus muscle extends the sacrum (upward and forward motion) and decreases the iliac inclination, thus tending to maintain both elements of the unstable slip.

7. The scoliosis disappeared in recumbency and reappeared when recumbency ceased. Therefore, the cause of the scoliosis did not lie within the presacral vertebral column, but in the effort of the spinal muscles to balance the vertebral column upon a foundation that had shifted from its normal position*.

The two sacro-iliac slips shown in this case were a sufficient cause and the only presenting cause of the alternating sciatic scoliosis. They represent derangements in the second type of normal sacro-iliac motion (lateral bending and rotation of the sacrum) in which the sacrum fails to follow the motion of an ilium, but slips past it and locks both the sacrum and that ilium in an abnormal position. For convenience, and because this type of sacral motion normally is secondary to iliac motion, we shall classify these slips hereafter as "iliac slips" and shall designate them as "increased-angle slips" or "decreased-angle slips".

There is another group of slips that we shall classify hereafter as "sacral slips" and shall designate as "flexion slips" or "extension slips". In sacral slips, one side of the sacrum travels with the contiguous ilium in the normal manner, but the joint becomes locked at one of the two extremes of normal motion. The mechanism of this slip becomes clearer if we remember that, as the inclination of an ilium increases, the sacrum is carried upward and forward *on the long arc of iliac motion.* When the normal limit of passive sacral motion is reached, any one of three events may transpire, if the angle of iliac inclination continues to increase, and if the symphysis pubis is not ruptured:

1. The sacrum may flex (move backward and downward on the short arc of normal sacral motion), thus relaxing the posterior sacro-iliac ligaments and allowing a further increase in the inclination of the advancing ilium. This is the normal action that we described in the second article of this series.

2. When a point is reached beyond which the sacrum cannot follow the advancing ilium, that side of the sacrum may slip backward and downward as the iliac angle increases. This is the "increased-angle slip" that we have just described.

3. If the sacrum is flexed completely and is so tightly wedged into the iliac mortise that an iliac type of slip cannot occur, the interlocked articular surfaces of the advancing ilium and of the sacrum act as a pair of enmeshed gears. The large iliac gear forces the small sacral gear upward and forward into extension at the expense of the posterior sacro-iliac

* The correlation of ligamentous tenderness with the distribution of telalgia, of which this case offers a striking example, was covered thoroughly in the first article of this series.

ligaments. Sacral extension loosens the iliac mortise, thus allowing the teeth of the imperfect gear to jump a cog and become jammed. This is the "extension slip" in which the sacrum and one ilium are locked in a position of sacral extension and increased iliac inclination. The "flexion slip" locks a sacro-iliac joint in a position of sacral flexion and decreased iliac inclination.

Sacro-iliac slips were present in 326 (64.0 per cent.) of our 506 cases. Of these 326 cases, 166 (51.0 per cent.) showed unilateral or bilateral sacral slips; 85 (26.0 per cent.) showed a sacral slip in one joint and an iliac slip in the other joint, and 75 (23.0 per cent.) showed unilateral or bilateral iliac slips. Three findings were common to every one of these 326 cases:

1. A history of sacrarthrogenetic telalgia;
2. Tenderness of the posterior sacro-iliac or sacro-ischial ligaments;
3. Lateral spinal scoliosis.

SUMMARY AND CONCLUSIONS

1. The authors have found twenty-two cases of alternating scoliosis mentioned in the literature. The apparent rarity of this condition is due to the fact that only the more spectacular cases have been reported.

2. The authors have found sixty-eight cases of alternating scoliosis in their records of 506 examinations for low-back disability. Six cases showed the spectacular type of active alternation.

3. The pain of alternating scoliosis is the typical sacrarthrogenetic telalgia that is caused by pathological tension in the extra-articular ligaments of the upper sacral joints.

4. The scoliosis is caused by one or more fixed pathological positions of one or more of the upper sacral joints.

5. Alternation is due to a change in the fixed pathological position of one or more of the upper sacral joints.

6. Either sacro-iliac joint may become fixed in one of four pathological positions (sacro-iliac slips) which the authors have classified as follows:

   a. Sacral slips:
      (1) Flexion slips;
      (2) Extension slips.
   b. Iliac slips:
      (1) Increased-angle slips;
      (2) Decreased-angle slips.

REFERENCES

1. Blencke, Hans: Die Scoliosis ischiadica alternans. Arch. f. Orthop. u. Unfall-Chir., XVIII, 63, 1920.
2. Brewster, A. H.: Scoliosis. *In* Loose-Leaf Living Surgery, III, Chap. I, p. 182 N. New York, Thomas Nelson & Sons.
3. Bucholz, C. H.: A Study of the Condition Frequently Called "Sciatic Scoliosis". Am. J. Orthop. Surg., X, 528, May 1913.
4. Calissano, Giovanni: Su di un caso di scoliosi sciatica alternante. Chir. d. Org. di Movimento, IX, 158, 1924.

5. CAPENER, NORMAN: Alternating Sciatic Scoliosis. Proc. Roy. Soc. Med., XXVI, Part I, 425, 1933.
6. DAINELLI, M.: Su di un caso di scoliosi sciatica alternante. Riforma Med., XLIII, 872, 1927.
7. DUCAMP ET CARRIEU: Scoliose alternante d'origine sciatique. Bull. et Mém. Soc. Méd. d. Hôp. de Paris, XLIV, 265, 1920.
8. EHRET, H.: Beiträge zur Lehre der Scoliose nach Ischias. Mitteil. a.d. Grenzgeb. d. Med. u. Chir., IV, 660, 1899.
9. FAIRBANK, H. A. T.: Discussion. Proc. Roy. Soc. Med., XXVI, Part I, 429, 1933.
10. FOPP, CHR.: Ein seltener Fall von Scoliosis neuromuscularis ischiadica. Ztschr. f. orthop. Chir., VI, 435, 1899.
11. HIGIER, H.: Ueber eine sehr seltene Form der alternirenden Scoliose bei Ischias. Neurol. Centralbl., XIV, 962, 1895.
12. LÉRI, ANDRÉ: Contribution à l'étude pathogénique des scolioses dites sciatiques. Scolioses alternantes: rachis à ressort et vertèbre en tiroir. Bull. et Mém. Soc. Méd. d. Hôp. de Paris, XLIII, 758, 1919.
13. LORD, J. P.: Discussion. Am. J. Orthop. Surg., X, 566, May 1913.
14. MAYER, MAURICE; ET TESTU, CLAUDE: Scoliose alternante avec rachis à ressort par vertèbres cunéiformes "en tiroir". Bull. et Mém. Soc. Méd. d. Hôp. de Paris, L, 124, 1926.
15. MAYER, OTTO: Ueber einen Fall von Ischias scoliotica alternans. Freiburg i. Br., H. M. Poppen & Sohn, 1895.
16. PHULPIN, ÉMILE: La sciatique en particulier, contribution à l'étude des scolioses homologues et alternantes, des troubles de la sensibilité et des réactions électriques. Thèse de Paris. Paris, 1895.
17. PITKIN, H. C.: Prone Knee Flexion: In Differential Diagnosis of Low Back Pain. California and West. Med., XXXVIII, 51, 1933.
18. PITKIN, H. C., AND PHEASANT, H. C.: Sacrarthrogenetic Telalgia. I. A Study of Referred Pain. J. Bone and Joint Surg., XVIII, 111, Jan. 1936.
Sacrarthrogenetic Telalgia. II. A Study of Sacral Mobility. J. Bone and Joint Surg., XVIII, 365, Apr. 1936.
19. REMAK, E.: Alternirende Scoliose bei Ischias. Deutsche Med. Wchnschr., XVII, 257, 1891.
20. STEIN: Cited by Calissano.
21. STEINDLER, A.: Compensation *vs.* Correction in the Treatment of Structural Scoliosis. J. Bone and Joint Surg., VIII, 570, July 1926.
22. VULPIUS, OSCAR: Ein Fall von alternirender Scoliosis neuropathica. Ztschr. f. orthop. Chir., IV, 1, 1896.

STUDY OF FUSION OF THE SPINE WITH PARTICULAR REFERENCE TO ARTICULAR FACETS *

BY S. L. HAAS, M.D., SAN FRANCISCO, CALIFORNIA

From the Surgical Laboratory, Stanford Medical School

It is twenty-four years since Hibbs performed his first spinal fusion on January 8, 1911. The operative procedure at that time consisted of interlocking the denuded spinous processes and was a marked advance over the operations of Chipault and Hadra, who used wire sutures, and of Lange, who placed a wire or celluloid strips along the spinous processes. In the report of further operations by Hibbs in 1912 it is noted that, in addition to interlocking the spinous processes, he raised up sections of bone from the laminae. It was not until 1918 that the destruction of the articular facets was instituted and the operation was developed to its present refinement. This operative procedure of Hibbs gives to orthopaedic surgery one of the most exacting techniques based on sound physiological and mechanical principles, and marks an epoch in this specialty.

Although no mention is made as to the reasons for each one of these additions, it can be presumed that they were for the specific purpose of hastening union and giving firmer fixation and maximum efficiency.

Six months after Hibbs's report Albee described his well-known operation in which the spinous processes are fixed by a tibial graft. Albee claimed that the preservation of the spinous processes and the posterior spinal ligaments with their leverage action was very important. He also stressed the importance of keeping one-half of the spinous process intact in order to allow better vascularization of the bone grafts. It is interesting that de Quervain in 1911 independently employed a bone graft to immobilize the lower cervical spine for dislocations of the fifth and sixth cervical vertebrae. Numerous modifications of the methods of Hibbs and Albee have been proposed since the original operations.

This investigation is not concerned with the merits of the various types of operations, but with a study of the changes in the articular facets following the fusion of the spinous process alone or in conjunction with the laminae. This is of importance from an academic as well as from a practical standpoint. It is a study of the changes in the intervertebral articulations following extra-articular fusion. Little information is obtainable relative to the changes that take place in these articulations after a spinal fusion in which they are not destroyed.

Albee, in December 1911, performed some interesting experiments in which he placed a bone graft in the spinous process of a dog. He obtained a successful fusion, but made no mention of the changes in the

* Read by title at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 13, 1936.

articular facets. He also carried out several experiments in which the spinous processes were interlocked without a bone graft. There was no immobilization of the animals after the operation and he reported that no union took place even between the spinous processes.

De Quervain and Hoessly, in 1916, experimentally transplanted bone into the spines of dogs, but they made no mention of the changes in the articulations.

In the experiments that form the basis of this report the spinous processes were made to interlock with each other. In some of the operations, in addition to the fusion of the processes, bone was thrown up from each lamina and made to contact with bone from the laminae of the adjoining vertebrae above and below. In other experiments, in addition to the interlocking of the spinous processes and the laminae, the articular facets were destroyed on one side only. A study was then made of the spine, particular attention being directed to the articular facets which had been destroyed. Some surgeons have claimed that it is not necessary to destroy the facets and that sufficient fixation will be obtained by the fusion of the spinous processes. It has also been suggested that secondary changes will take place in the facets, with their subsequent fusion.

If spontaneous fusion should take place in the facets, the operator would be spared a considerable amount of painstaking work, and the operation would be simplified and shortened.

It is hoped that the following experiments will throw some light on these interesting questions. The experiments will be considered under the following headings:

(1) Simple fusion of the spinous processes;

(2) Fusion of the spinous processes and union of the laminae;

(3) Fusion of the spinous processes, laminae, and the facets on one side.

SIMPLE FUSION OF THE SPINOUS PROCESSES

EXPERIMENT 1. Dog 3, six months old. Duration of experiment, thirteen days.

Operation: After having been exposed, the lumbar spinous processes were denuded by stripping off the surrounding tissues subperiosteally. The spinous processes were then split into several pieces and interlocked with fragments of bone from the spinous processes above and below.

Gross examination: A definite sense of firmness was found in the area of the spine which had been operated upon. There appeared to be some proliferation between the interlocked fragments of the spinous processes. The parts of the laminae near the spinous processes were covered by new osteoidlike tissue. The articular facets were unchanged, and free motion could be obtained on manipulation. On further exposure, the articular cartilages were found to be normal.

Roentgenographic examination: The roentgenogram showed no changes in the facets. There was interlocking of the fragments, but no osseous proliferation could be seen at this early stage.

EXPERIMENT 2. Dog 1, almost full-grown. Duration of experiment, twenty days.

Operation: After having been exposed and denuded by stripping off the muscles subperiosteally, the lumbar spinous processes were interlocked with each other. The animal was immobilized in plaster for two weeks.

Gross examination: In spite of the relatively short period of twenty days, there was considerable fixation in the area of operation. There was definite proliferation of new osteoid tissue between the processes, with a tendency to extend out over the laminae. The articular facets appeared in a normal position, and the articular cartilage of the facets appeared to be of normal color, thickness, and structure.

Roentgenographic examination: Roentgenograms showed no changes in the articular facets. The spinous processes appeared to be in apposition.

EXPERIMENT 3. Dog 2, young, full-grown. Duration of experiment, 170 days.

Operation: The spinous processes were interlocked with each other, but the laminae and articulations were not disturbed.

Gross examination: There was marked rigidity of the spine. Bony bridging between the spinous processes was noted but very little bone was thrown out on the laminae; only the parts near the spine were bridged across. Some of the articular facets were covered by new bone and appeared to be fused. However, on removal of this thin layer of new bone, the articular cartilages were found slightly changed, but the motion between the surfaces was less free than normal. In places there was some destruction of cartilage and what appeared to be beginning bridging across. The majority of the articulations showed restricted motion and thinning of the articular cartilage, but no union.

Roentgenographic examination: All of the articular facets could be seen very clearly in an oblique view in the plane of the facets. Some appeared more indistinct than others. There was an osseous bridging between the spinous processes. In some places there were rarefied areas which might be cleavage planes of osteoid tissue extending across the spinous processes.

Microscopic examination: There was definite articular cartilage on both sides of the partially fused facets. The structure of the cartilage was somewhat thinner than normal, and the nuclei were not quite as numerous and as regular as in normal cartilage. No osseous union was found.

Where the spinous processes only were interlocked, there was considerable fixation of the spine in the area of operation, even as early as twenty days. At the end of 170 days there was firm union of the spinous processes, but there were very few secondary changes in the articular facets. Some showed a bridging over on the surface, and it took considerable force to obtain any motion between the facets.

FUSION OF THE SPINOUS PROCESSES AND UNION OF THE LAMINAE

EXPERIMENT 4. Dog 4, three months old. Duration of experiment, thirty-four days.

Operation: The spinous processes were exposed, and the muscles were stripped off subperiosteally to either side. No attempt was made to expose the articular facets. The spinous processes were split and made to interlock with those above and below. Sections of bone were thrown up from the laminae, but special effort was made not to approach the articular facets. The animal was immobilized in plaster for twenty-eight days.

Gross examination: There was considerable rigidity between the spinous processes with evidence of bone proliferation. The articular facets could be distinguished and there was considerable motion between the two articular cartilages.

Roentgenographic examination: The articular facets showed a normal outline with no evidence of change in the articular cartilage.

EXPERIMENT 5. Dog 5, three months old. Duration of experiment, 205 days.

Operation: The spinous processes were exposed and the muscles were stripped off subperiosteally. The spinous processes were split in half and then interlocked. Small sections of bone were thrown up from each lamina to the laminae above and below and over the articular facets. The articular facets were not destroyed.

Gross examination: There was firm fusion of the spine and of the laminae in the area

FIG. 1

Experiment 5. Dog 5. Duration of experiment, 205 days. The spinous processes and the laminae were fused by operation. The intervertebral articulations were not disturbed. All of the articular cartilages were present, but distorted. Some of the joints showed partial ankylosis. The arrows point to the joints which showed the most changes.

of operation. No evidence of motion could be ascertained even in the articular facets. The articular facets were not visible, as a layer of bone had formed over them. Furthermore, there was marked distortion in the plane of the facets. It appeared as though the new bone, which was formed about the laminae, had displaced the facets away from the spinous processes and had rotated the plane of the joints. After the removal of the superficial layer of bone, some of the articular cartilage of the facets could be found in apposition to a similar layer of cartilage. It was possible to peel one layer off the other, but the approximation was so close that no movement took place between them. One of the articular facets was entirely obliterated, while several others showed partial destruction and partial fusion.

Roentgenographic examination: The articular facets on both sides could be distinguished, but they showed marked changes in size, shape, and outline. Several could scarcely be discerned and appeared to be entirely fused, which agreed with the gross findings (See Figure 1).

Microscopic examination: The one facet which appeared to be fused, both in the gross and in the roentgenographic examinations, showed a small portion of articular cartilage with fibrous tissue on the surface. The cartilage was undergoing degeneration, being poorly stained and irregular in structure. There was some evidence of osseous union. A microscopic section from one of the joints that appeared to be fused, in which two closely applied articular cartilages were found, showed two layers of cartilage, one of which was thinner and more irregular than the other.

In this experiment in which the facets were not destroyed, but were merely covered by bone thrown over them from the laminae, there were definite secondary changes in the articular facets. There was good fixation of the overlying tissues and it was probably because of the loss of motion that the secondary changes took place in the articular facets. Several of the facets appeared arthrodesed and only part of the cartilage was found. Other facets showed degenerative changes in the cartilage. These changes were not as marked as in the next series where the facets were destroyed on one side. There was no evidence of motion and none could be produced by manipulation.

FUSION OF THE SPINOUS PROCESSES, LAMINAE, AND THE FACETS ON ONE SIDE

EXPERIMENT 6. Dog 7, young pup. Duration of experiment, twenty-seven days. *Operation:* An incision was made over the spinous processes. The muscles were

reflected subperiosteally well out to the articular facets. On the left, three articular facets were destroyed and two others were covered by bone from the laminae. Nothing was done to the facets on the right. The animal was immobilized in plaster for twenty-seven days.

Gross examination: There was definite increased rigidity of the spine in the area of operation. Definite osteoid and osseous tissue could be seen between the spinous processes. The articular facets on the left showed very little, if any, evidence of motion. The cartilage was entirely absent in some, while in others it was only partially present. On the right, where the articular cartilages were not destroyed, there was a little motion in all the articular facets. There was no appreciable change in the articular cartilages, although they appeared slightly thinner than normal.

Roentgenographic examination: The spinous processes were well interlocked. There was no definite evidence of osseous union. The articular facets on the right, which were not destroyed, appeared normal. Those on the left, which were curetted, had irregular outlines. They showed definite signs of destruction, some more than others, depending on the amount of operative interference.

Microscopic examination: There was a marked amount of callus between the spinous processes. The articulations which were destroyed showed some small remnants of articular cartilage of irregular structure. The cancellous bone was poorly stained and there was very little evidence of callus. The articular cartilages that were not destroyed were of normal appearance and structure.

EXPERIMENT 7. Dog 6, full-grown. Duration of experiment, 160 days.

Operation: The spinous processes were exposed, and the muscles and fascia were stripped off subperiosteally well out to the articular facets. On the right side the articular facets were destroyed, while on the left they were left intact. The animal was immobilized in plaster for six weeks.

Gross examination: There was firm union between the spinous processes. On dissection, several small cleavage planes were found extending transversely across the fused area. These lines of cleavage appeared to bear some relation to the intervertebral articulations on each side. The articular facets on the right, which were destroyed, were completely fused. In several, there were some small particles of cartilage which may have been remnants of articular cartilage or callus which was not ossified. There were no signs of any joint spaces or even two leaves of cartilage.

On the left side, where the articular facets were not destroyed, there was absolutely no sign of any motion. When the region of the articulations was exposed, they appeared completely ankylosed. After the superficial layer of bone had been removed, remnants of the articular cartilage could be made out. There were no joint spaces and in only one joint could two layers of cartilage be found. These two layers of cartilage were very closely and firmly approximated.

Roentgenographic examination: The facets on the right side were destroyed and appeared to be completely arthrodesed. On the left

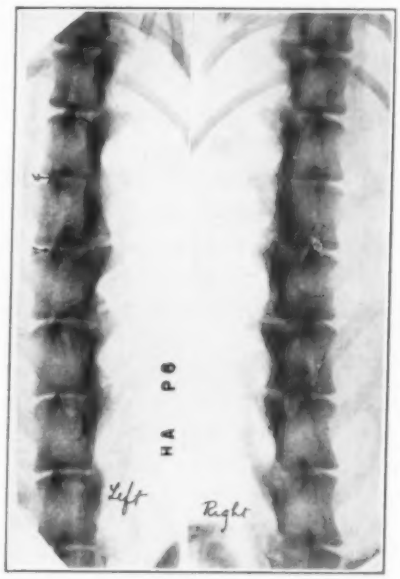


FIG. 2

Experiment 7. Dog 6. Duration of experiment, 160 days. The spinous processes, laminae, and intervertebral articulations on the right were fused at operation. The arrows indicate two of the intervertebral articulations on the left which underwent fusion without operative destruction. The remnants of the articulations on the left showed varying degrees of injury.

side, where the facets were not destroyed, there were irregular rarefied areas representing what remained of the articulations. One joint appeared to be completely destroyed. (See Figure 2.)

Microscopic examination: Sections were made of two of the joints on the non-operated side. One, which appeared fused on macroscopic study, showed a small remnant of articular cartilage which was poorly stained and appeared to be undergoing degeneration. The greater part of the tissue consisted of normal appearing trabeculated bone within which were a few strands of cartilage tissue such as would be found in an arthrodesed joint. The other section from the area where there was gross cartilage present showed fairly normal articular cartilage beneath which were normal trabeculae and marrow.

In those cases in which the facets on one side were destroyed there was more rigidity of the spine than in the cases in which the facets were not destroyed. The articular facets on the non-operative side showed very marked secondary changes. There were no signs of joint spaces and some of the joints were practically fused, only small remnants of cartilage being present. One set of the facets was in such close apposition that the two articular cartilages could be separated only by force.

SUMMARY

In the experiments in which the spinous processes alone were fused, there were practically no changes in the articular facets.

When, in addition to the fusion of the spinous processes, sections of bone were thrown up from the laminae and over the articular facets, secondary changes took place in the facets that had not been destroyed. In one experiment of 205 days' duration, several of the articulations were partially arthrodesed.

If, in conjunction with the fusion of the spinous processes, the articular facets were destroyed on one side, marked changes took place in the articular facets of the opposite side. After 160 days very slight remnants of articular cartilage were found in some of the undestroyed articulations. No signs of joint spaces were found, although some joints showed the persistence of two articular cartilages.

There was marked distortion of the plane of the facets with heaping up of bone about them on the side which had not been operated upon, as well as on the side upon which an operation had been performed.

The changes described took place in normal spines. One would expect greater changes if a diseased condition or abnormal pressure as in scoliosis were present.

CONCLUSIONS

1. Fusion of the spinous processes alone produces no secondary changes in the intervertebral articulations.

2. Fusion of the spinous processes and laminae with bone thrown up over the intervertebral articulations causes loss of motion and partial destruction of some of the intervertebral joints.

3. After fusion of the spinous processes and laminae and destruction of the intervertebral articulations on one side, marked changes take place

in the articulations on the opposite side, some of the articulations being almost completely ankylosed.

4. It is advisable to destroy the intervertebral articulations in the Hibbs spinal-fusion operation in order to obtain the most rapid and efficient fixation.

REFERENCES

ALBEE, F. H.: Transplantation of a Portion of the Tibia into the Spine for Pott's Disease. A Preliminary Report. J. Am. Med. Assn., LVII, 885, 1911.

Bone-Graft Surgery. Philadelphia, W. B. Saunders Co., 1915.

The Bone-Graft Operation for Tuberculosis of the Spine. Twenty Years' Experience. J. Am. Med. Assn., XCIV, 1467, 1930.

BROWN, L. T.: Beef Bone in Stabilizing Operations of the Spine. J. Bone and Joint Surg., IV, 711, Oct. 1922.

CHIPAULT, A.: La réduction des gibbosités pottiques. Presse Méd., V (Premier Semestre), 240, 1897.

DE QUERVAIN, F.: Zur Behandlung veralteter Wirbelluxationen mittelst Osteoplastik. Beitr. z. klin. Chir., LXXIX, 155, 1912.

DE QUERVAIN, F., AND HOESSLY, H.: Operative Immobilization of the Spine. Surg. Gynec. Obstet., XXIV, 428, 1917.

HADRA, B. E.: Wiring of the Vertebrae as a Means of Immobilization in Fractures and Pott's Disease. Times and Register, XXII, 423, 1891.

HIBBS, R. A.: An Operation for Progressive Spinal Deformities. A Preliminary Report of Three Cases from the Service of the Orthopaedic Hospital. New York Med. J., XCIII, 1013, 1911.

An Operation for Pott's Disease of the Spine. J. Am. Med. Assn., LIX, 433, 1912.

Treatment of Vertebral Tuberculosis by Fusion Operation. Report of Two Hundred and Ten Cases. J. Am. Med. Assn., LXXI, 1372, 1918.

HOESSLY, HANS: Die osteoplastische Behandlung der Wirbelsäuleerkrankungen, speziell bei Verletzungen und bei der Spondylitis tuberculosa. Pathologisch-anatomische, klinische und experimentelle Studie. Beitr. z. klin. Chir., CII, 153, 1916.

LANGE, FRITZ: The Operative Splinting of the Vertebral Column in Pott's Disease. Surg. Gynec. Obstet. XLIV, 668, 1927.

Die Fremdkörpereinpflanzung in der Orthopädie. Jahresk. f. Ärztl. Fortbldg., XI, Dezemberheft, 47, 1920.

THE KNEE-FLEXION TEST FOR PATHOLOGY IN THE LUMBOSACRAL AND SACRO-ILIAC JOINTS

BY I. WILLIAM NACHLAS, M.D., BALTIMORE, MARYLAND

From the Orthopaedic Department, The Johns Hopkins Medical School

Pain in the lower part of the back may be due to involvement of the gynecological, genito-urinary, gastro-intestinal, retroperitoneal, or skeletal tracts. In addition to this, the somatic manifestations of the neurotic and the wilful prevarications of the malingerer may focus attention on this area. Tests which help allocate the pathology to the particular system involved are therefore valuable. A number of such tests have already been described. The following test is offered because it is simple and because, by its remote control, it avoids the confusion that attends direct manipulations of structures near the affected area.

In this test the patient lies relaxed in a prone position on a rigid examining table, and the examiner flexes the knee by raising the foot up from the table. If the test is positive, the patient experiences pain in the sacro-iliac or lumbosacral region, and at times along the nerves that run in front of these joints. The radiating pain follows the course either of the sciatic nerve, along the back of the limb to the calf, or the external cutaneous nerve of the thigh, on the outer side of the thigh to the knee. If the patient has no skeletal pathology in the lower part of the back, he will experience no pain, or only a feeling of tension in the front of the thigh.

The possibilities for error in technique are few. The only necessary precautions are: (1) the table should be flat and non-yielding; (2) the patient should lie prone and relaxed, with the limbs side by side; and (3) the leg should be passively raised directly up to flex at the knee. It is occasionally desirable to rest a hand lightly on the back to keep the patient from buckling at the hips. (See Figure 1.)

FIG. 1

The knee-flexion test for low-back pathology.

The principle of this test is simple. When the knee joint is flexed, the patella and the rectus femoris

FIG. 2

Diagram to indicate the force exerted on the ilium when the knee is flexed. The patella P is pulled down and, through the rectus femoris muscle, exerts a displacing force along the line SP on the anterior-inferior iliac spine S. Since the ilium rests on the head of the femur and rotates around C, the displacement will take place along the arc A.

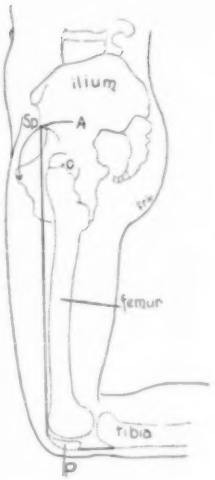


FIG. 2

muscle which is attached to it are pulled distally. The long head of the rectus femoris is attached to the anterior-inferior iliac spine about two inches in front of the center of rotation of the innominate bone on the femur. Consequently, the flexion of the knee tends to rotate the ilium forward and downward. (See Figure 2.) This torsional force manifests itself as a strain on the nearest sacro-iliac joint. When this joint is intact, the sacrum is carried with the ilium, so that strain is applied either to the lumbosacral or to the opposite sacro-iliac joint. The strain on a diseased joint causes pain in the joint itself, but the displacement produced, if enough to cause pressure on the adjacent nerve trunks, is often recognized by pain referred to the skin-sensory areas of the affected nerve.

In the decade that has elapsed since the author first presented this observation the test has been used in many hundreds of cases. There are some definite conclusions to be drawn as to its value. A positive test may be accepted as an indication that disease is present in the lower part of the back, and, when the response is felt in a specific joint, it is safe to assume that that joint is the affected one. On the other hand, one cannot deduce the type of the involvement,—that is, one cannot differentiate trauma from arthritic affection. A negative reaction does not rule out skeletal pathology. Occasionally one obtains a positive reaction with this manoeuver when the Goldthwait or so called Lasègue test is negative. Generally speaking, however, the rectus femoris pull is not as frequently positive as is the hamstring test. The knee-flexion test has one particular advantage, of especial value in treating nervous patients,—namely, the normal tension discomfort produced by the manoeuver is felt only on the front of the thigh, so that it can easily be distinguished from the "positive" reaction which is felt on the posterior aspect. Finally, the simplicity of the procedure recommends it as an additional diagnostic measure.

FRACTURES OF THE PROXIMAL PHALANGES

Alignment and Immobilization

BY S. A. JAHSS, M.D., NEW YORK, N. Y.

From the Hospital for Joint Diseases *

It is an undisputed fact that fractures involving the proximal phalanges of the hand *must* be immobilized in *flexion*. This is due to the constant deformity present,—flexion of the proximal fragment and extension of the distal fragment. (See Figures 1 and 4.)

To align these fragments and to hold them in the corrected position, it has been the custom to bend the phalanx over an anterior pliable metal splint and to fix it in that position. This correction is accomplished and maintained by the upward pressure of the convex portion of the splint against the anterior angulation of the fracture and the counter or downward pressure on the ends of the phalanx. When marked flexion is necessary, this upward pressure may be strong enough to cause local necrosis of the skin and the conversion of a simple fracture into a compound, infected one. This happened in one of our cases.

The author's attention was focused on this problem when he was called to see a patient who had sustained fractures of the proximal phalanges of the third, fourth, and fifth fingers (Fig. 1). Three separate

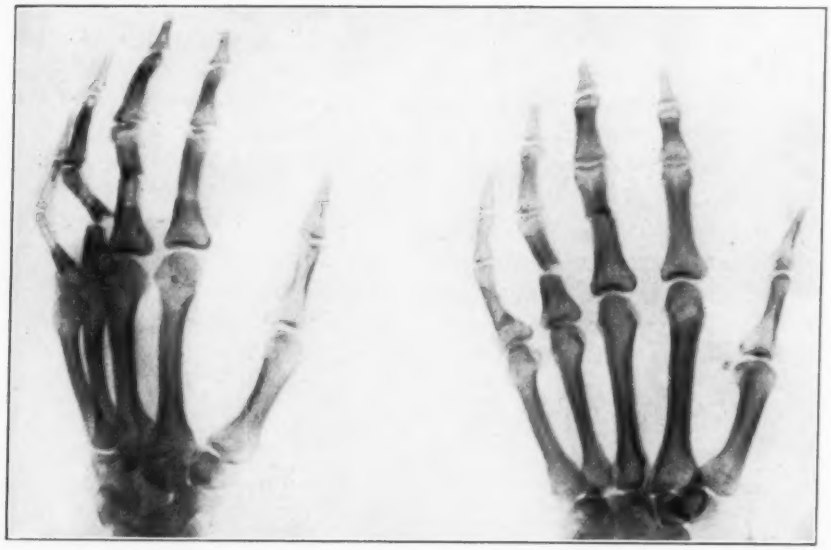


FIG. 1

Case 1. Note the typical anterior angulation involving the proximal phalanges of the third, fourth, and fifth fingers.

* Service of H. C. Frauenthal, M.D.

FIG. 2

Case 1. After reduction. Note the alignment of the fractures of the fourth and fifth fingers; also the moderate dorsal angulation of the third finger. This was corrected by partially extending the metacarpophalangeal joint and flexing the proximal phalangeal joint and immobilizing the finger in that position. (See Figure 9-B.) Note the angles between the metacarpals and the proximal phalanges. In the fifth finger, it is 70 degrees; in the fourth, 90 degrees. Note also only partial flexion at the proximal phalangeal joints of the fourth and fifth fingers.

FIG. 2

splints on three contiguous fingers were impractical; moreover, no splint could control the fracture in the fifth finger. Every conceivable method was tried, but without success. A simpler method was then devised which corrected the angulation and provided immobilization. Reduction will first be considered.

CORRECTION OF ANGULATION

Indirect Method

It might be appropriate at this point to call attention to

FIG. 3

Case 1. End result: excellent alignment; no angulation.

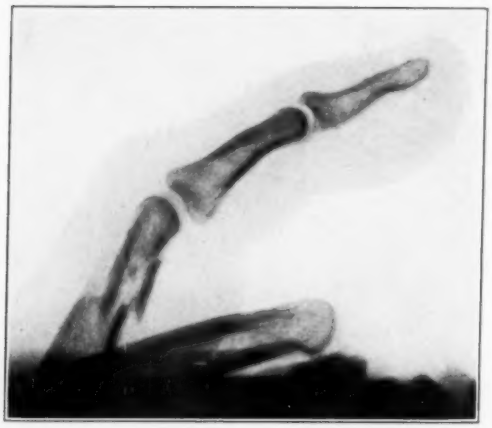


FIG. 4

Case 2. Fracture of the proximal phalanx of the fifth finger. Anterior angulation.

the fact that motion in the proximal interphalangeal joint is *equal* in *all fingers*. In these joints, the angle of greatest flexion is about 60 degrees. When this joint is flexed to its limit, tension on the articular (posterior) capsule takes place. In the case of a fracture of the proximal phalanx, any attempt to flex this joint further will, through the taut articular capsule, only move the head of the phalanx toward the palm,—that is, into flexion. This was demonstrated in Case 3, in which an operation was performed because of a previous malunion. Osteotomy was done and the rotation deformity was overcome (Fig. 7). When the proximal phalangeal joint was flexed to its full limit, the distal fragment also went into flexion, and the amount of flexion of this fragment was in direct ratio to the amount of tension on the articular (posterior) capsule. As soon as this joint was relaxed, the distal fragment went into a position of extension, and anterior angulation at the fracture site took

FIG. 5

Case 2. Reduction by partial flexion at the metacarpophalangeal joint and full flexion at the proximal phalangeal joint. The angle between the metacarpal and the phalanx is 135 degrees. Full flexion at this joint would make an angle of 70 degrees.

FIG. 6

Case 2. Anteroposterior view, showing excellent alignment.

FIG. 7

Case 3. Osteotomy for malunion. Alignment and immobilization were obtained by partial flexion at the metacarpophalangeal joint and full flexion at the proximal phalangeal joint.

place. It was also demonstrated at this time that, if more than slight flexion was present in the metacarpophalangeal joint during these manoeuvers, dorsal angulation took place. This method can control almost all fractures of the proximal phalanges.

Should this procedure prove ineffective, one can then employ direct flexion of the distal fragment.

Direct Method

Direct flexion is obtained by placing the thumb on the anterior angulation and, with the other hand, grasping the head of the phalanx and flexing it. The proper amount of flexion of this fragment is dependent upon the degree of angulation present in the fracture. To prevent any slipping, flexion of the *entire phalanx* is now in order. The expansion of the extensor digitorum communis over the phalanx will splint the fragments, but, as flexion in the metacarpophalangeal joint approaches 90 degrees, tension on the dorsal (posterior) ligament begins to take place. This tension will fix the proximal fragment, and further flexion of the finger will only influence the distal fragment and produce a dorsal angulation,—that is, an overcorrection of the original deformity. Since the angle of

FIG. 8

Strapping. Note *full* flexion at the *metacarpophalangeal* joint and *partial* flexion at the *proximal* phalangeal joint.

greatest flexion in the metacarpophalangeal joints is *not* equal in all the fingers, the amount of flexion will necessarily vary. It is greatest in the fifth finger and gradually diminishes, in order, from the fifth to the second finger, inclusive. The proximal interphalangeal joint must *not* be tensed when direct flexion is used, as such tension would overcorrect the angulation.

IMMOBILIZATION

To secure immobilization, two narrow strips of adhesive are sufficient,—one running from the dorsum of the hand, longitudinally over the finger, to the palm; and the other, transversely across the dorsum of the hand and in the palmar direction over the head of the proximal phalanx or the shaft of the middle phalanx. (See Figures 8 and 9-B.) If there is any space between the palm and the finger, a piece of absorbent cotton may be introduced between them.

For a fracture of the middle phalanx, where an antérior angulation is present, simple strapping of the distal phalanx to the proximal phalanx, with the proximal and distal phalangeal joints in full flexion, will both overcome the anterior angulation and immobilize the fragments (Figs. 9-A, 10-A, and 10-B). In Figure 9-A the strapping on the distal phalanx is too close to the base. Instead it should pass over the finger-nail and around the dorsum and sides of the proximal phalanx close to the web. The principle involved here is basically the same,—*i.e.*, taking advantage

FIG. 9-A

Strapping for fractures of the middle phalanx when *anterior* angulation is present.

FIG. 9-B

Partial flexion at the *metacarpophalangeal* joint and *full* flexion at the *proximal* phalangeal joint

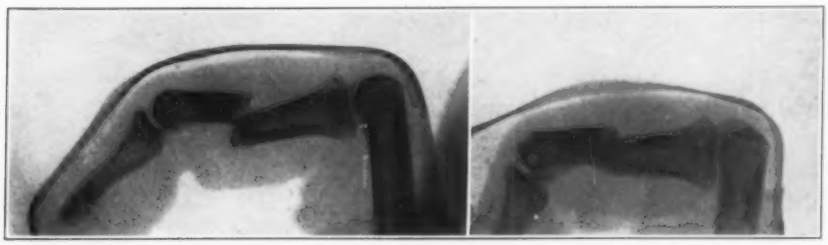


FIG. 10-A

Case 4. Oblique fracture of the middle phalanx with anterior angulation.

FIG. 10-B

Case 4. Reduction and immobilization by strapping. See Figure 9-A.

of the normal physiological restriction of motion at the proximal and distal interphalangeal joints.

SUMMARY

By utilizing the normal limits of flexion at *either* the proximal interphalangeal *or* the metacarpophalangeal joint, the anterior angulation present in fractures of the proximal phalanges can be overcome. For fractures of the middle phalanx moderate flexion at the *proximal and distal* interphalangeal joints is necessary to accomplish reduction.

Immobilization is accomplished by simple strapping.

The author is indebted to Dr. Louis Sachs and Dr. David Sloane, who treated Cases 2 and 4 according to the author's method.

PANASTRAGALOID ARTHRODESIS

A Study of End Results in Eighty-Five Cases

BY W. R. HAMSA, M.D., IOWA CITY, IOWA

From the Department of Orthopaedic Surgery, University of Iowa*

The radical eradication of all joints about the astragalus was first described by Lorthioir and was designed for equinovarus deformity, paralytic or congenital in origin. The technique necessitated the temporary removal of the astragalus, after which it was replaced. The result controlled all deforming factors of the flail foot. This method was modified by Albee and later by Steindler who stressed the applicability of the procedure when quadriceps weakness or paralysis was associated with the flail foot.

In a case of quadriceps paralysis, the patient usually reenforces the instability of the leg in walking by placing the hand on the involved knee, or he relies on a brace which holds the knee in extension. When the foot and tibia are fused in 15 to 20 degrees of equinus and they function as one lever, the pressure of superimposed body weight on the forefoot produces a backward thrust of the upper end of the lever, which passively extends the knee joint to its range limit, thus producing an extremity upon which the individual may place his weight temporarily without danger of collapse of the knee. Two requisites, however, are necessary: the knee joint must allow full extension or a few degrees of hyperextension, and some mechanism must protect the knee joint against ultimate genu recurvatum. This is normally the function of the hamstring muscles and of the capsule of the posterior joint, hence the importance attached to the strength of the hamstring muscles in these cases. In the absence of hamstring action, the capsule assumes the burden unless reenforced by some stabilizing reconstruction as an anterior bone block or a posterior capsuloplasty.

The technique of panastragaloid arthrodesis is as follows: A tourniquet is applied at the midthigh. Through a Kocher incision on the lateral aspect of the ankle, the peroneal tendons and the calcaneofibular and astragaloscaphoid ligaments are severed. The tibiotarsal and midtarsal joints are opened by extreme supination and adduction of the forefoot. This exposes the articular surfaces of the tibia, fibula, astragalus, and scaphoid which, in the order named, are denuded of cartilage with a narrow chisel. The astragalus is then pulled upward and the subastragalar and calcaneocuboid joints are exposed and denuded of cartilage in a similar manner. During the whole procedure the astragalus remains attached by its inferior ligaments. Varus or valgus of the os calcis may

* Service of Arthur Steindler, M.D.

be corrected by appropriate wedges removed from the subastragalar joint. Forefoot abduction and adduction are corrected by wedges removed from the astragalar head and neck. After the astragalus is replaced, the wound is closed and a gutta-percha drain is inserted for twenty-four hours. The foot is placed in 15 to 20 degrees of equinus, in perfect lateral alignment, and immobilized in a long leg cast for three to four months. The patient may then bear weight with no other support than an ordinary shoe.

Of 100 cases of panastragaloid arthrodesis performed for paralytic deformities, eighty-five have adequate details available to make possible the following summary. These patients may be divided into three groups according to their muscular assets at the time of operation.

Group I: Twenty-four patients presented severe paralysis of the entire leg,—poor or absent gluteal musculature, poor or absent hamstrings, absent quadriceps, poor or absent ankle and foot musculature. The results obtained by the operation are tabulated in Table I.

TABLE I

GROUP I—TWENTY-FOUR CASES

Result	Cases		Average Age (*Years*)	Average Years Observed	Preoperative Findings	*Cases*	Postoperative Findings	*Cases*
	No.	*Per Cent.*						
Good	10	41.7	13.3	3.3	Calcaneus	2	Clinical fusion in good position	10
					Valgus of foot	2		
					Varus of ankle	2		
					No deformity	4		
Fair	4	16.6	12.7	5	Varus of foot	2	Hyperextension of knee	1
					Varus and cavus of foot	1	Necessity for long leg brace	3
					Metatarsus varus	1	Clinical fusion in good position	4
Poor	10	41.7	15.8	2.6	Varus of foot	4	Varus of knee	2
					Varus of ankle	1	Flexion contracture of knee	2
					Equinus	4	Hyperextension of knee	1
					No deformity	1	Pain in ankle	1
							Valgus of foot	2
							No improvement	2
							Necessity for long leg brace	10

Group II: Twenty-five patients presented good gluteal and hamstring musculature, absent quadriceps musculature, and poor or absent ankle and foot musculature. The end results are shown in Table II.

Group III: Thirty-six patients presented good gluteal, quadriceps, and hamstring musculature, with associated paralytic flail foot in the majority of cases. Table III gives the end results.

Results are classified as "good", "fair", and "poor". A good result indicates a stable, painless foot with no necessity for support to the extremity. A fair result signifies improvement in gait without symptoms. A poor result indicates no improvement.

TABLE II

GROUP II—TWENTY-FIVE CASES

Result	Cases		Average Age (*Years*)	Average Years Observed	Preoperative Findings	*Cases*	Postoperative Findings	*Cases*
	No.	*Per Cent.*						
Good	20	80	12.3	4.3	Varus of foot	5	Clinical fusion in good position	20
					Equinus	4		
					Valgus of foot	2		
					Valgus of ankle	1		
					Cavus	2		
					Calcaneus	2		
					No deformity	4		
Fair	2	8	14	1.5	Varus of foot	1	10-degree flexion contracture of knee	1
					No deformity	1	10-degree equinus with knee instability	1
Poor	3	12	10.6	4.3	Valgus of foot	1	25-degree flexion contracture of knee	1
					Calcaneus	1	Pseudarthrosis of ankle with pain	1
					No deformity	1	Pseudarthrosis of ankle with calcaneus	1

Although this type of arthrodesis may be considered too radical for Group III, the results were so satisfactory, objectively and subjectively, that the procedure may be considered to be ideal for a flail foot in the case of an active individual of the laboring class. However, other types of stabilization and tendon transplantation might be considered for the nine cases in which the long muscles about the ankle functioned partially. These patients should be candidates for the usual triple arthrodesis and peroneal transplantation. The two fair results and the one poor result are accounted for by errors in technique.

TABLE III

GROUP III—THIRTY-SIX CASES

Result	Cases		Average Age (Years)	Average Years Observed	Preoperative Findings	Cases	Postoperative Findings	Cases
	No.	Per Cent.						
Good	33	91.6	12	4.4	Flail ankle and foot	24	Clinical fusion in good position	33
					75-per-cent. gastrocnemius strength	3		
					Additional 50-per-cent. peroneal strength	6		
					Severe foot deformity	0		
Fair	2	5.6	8.5	5	Varus of foot	1	25-degree equinus	1
					No deformity	1	Pseudarthrosis of ankle with pain	1
Poor	1	2.8	15	2	Mild valgus of foot	0	Anterior dislocation of astragalus with pseudarthrosis and pain	0

COMMENT

Crainz suggested the age of twelve years as the earliest age at which fusion of this type should be attempted. The youngest patient in this series was six years of age and no apparent difficulty was experienced in obtaining a fusion. There is, however, a good reason for delaying the procedure until the age of twelve years. The relative proportion of the cancellous part of the astragalus as compared to the cartilage is greater at this time and, therefore, the decrease in size after removal of the cartilage is correspondingly less. Hence, there is less shortening of the leg from the operative procedure, whereas fusion at an earlier age would contribute directly to the shortening of the involved extremity. Crainz, like Lorthioir, temporarily removed the astragalus to facilitate removal of cartilage and stated that this was a safe procedure. This step has not been followed in this series as the astragalus has always remained attached by its inferior ligaments, thereby partially preserving its blood supply. One case of apparent necrosis of the astragalus followed the temporary removal of the bone during this type of fusion for a traumatic arthritis in an adult.

CONCLUSION

Considering the entire series, the results were good in 74.1 per cent., fair in 9.4 per cent., and poor in 16.5 per cent. Eight fair and fourteen

poor results were obtained. Of these, sixteen were due to errors in indication, while six were due to errors in technique. It is evident, therefore, that proper selection and surgical technique will produce a stable foot and ankle, which also stabilizes the knee joint. Muscular requisites are good gluteal and hamstring action. Definite contra-indications are disalignment of the knee, such as a valgus, hyperextension, or flexion contracture.

REFERENCES

ALBEE, F. H: Orthopedic and Reconstruction Surgery. Industrial and Civilian. p. 765. Philadelphia, W. B. Saunders Co., 1919.

CRAINZ, SILVIO: L'artrodesi del piede per mezzo dell'astragalectomia seguita dā reimpianto parziale o totale dell'astragalo. Policlinico, XXXI, Sez. Chir., 1, 1924.

LORTHIOIR, J: Huit cas d'arthrodèse du pied avec extirpation temporaire de l'astragale. J. de Chir. et Ann. Soc. Belge de Chir., XI, 184, 1911.

STEINDLER, ARTHUR: The Treatment of the Flail Ankle; Panastragaloid Arthrodesis. J. Bone and Joint Surg., V, 284, Apr. 1923.

STABILIZATION OF PATHOLOGICAL DISLOCATION OF THE HIP IN CHILDREN

BY J. B. L'EPISCOPO, M.D., BROOKLYN, NEW YORK

Acute suppurative conditions of the hip joint in early childhood are quite common. In most of these cases a certain degree of absorption of the head and sometimes of the neck occurs, often resulting in a pathological dislocation of the hip or fibrous ankylosis. To the writer's knowledge, no adequate operation has been devised to stabilize such hips when dislocation has occurred. In discussing reconstruction operations of the hip, Campbell and Speed do not consider this type of pathological dislocation at all.

The author feels that the best way to stabilize these hips is to restore in some way the anatomical neck of the femur, so that it with the shaft produces an angle of approximately 125 degrees. The following operation was devised for that purpose.

The hip joint is exposed through the usual Smith-Petersen incision. The upper end of the femur is split from above downward sagittally. The medial portion includes whatever is left of the neck and about one-third of the width of the shaft of the femur. Before making the sagittal section in the femur, one should be sure that the toes point forward; otherwise the foot may be everted or inverted when the medial prong of the fork is placed in the acetabulum. The length of the bone incision depends on how long a neck is needed in each individual case. Then a greenstick fracture of the medial portion of the sectioned femur is produced, and the broken fragment is bent medially so that the upper end fits into the acetabulum. The amount of bending should be sufficient to produce an angle of about 125 degrees between the fragment and the shaft, thus restoring the normal neck on top of the shaft. Then the bent fragment is maintained in position by driving in a wedge of bone at the apex of the cleft between the two prongs of the upper end of the femur. This wedge of bone is taken from the crest of the ilium and is large enough to maintain the broken inner fragment at the desired angle with the shaft of the femur. It should be large enough to be jammed and held in position without the use of any sutures. As the upper end of the bone is placed into the acetabulum, it is best to abduct the limb, as this facilitates the procedure. When the angle is being produced between the broken fragment and the shaft, the extremity is adducted until the proper angle is obtained. It should be borne in mind that adduction tends to separate the two prongs of the fork produced,—that is, to produce a coxa vara; whereas abduction tends to bring the two prongs together,—to produce a coxa valga. The limb is held in the desired position of adduction to maintain the proper relationship while the wound is being closed, and a plaster-of-Paris spica is applied down to the toes. When

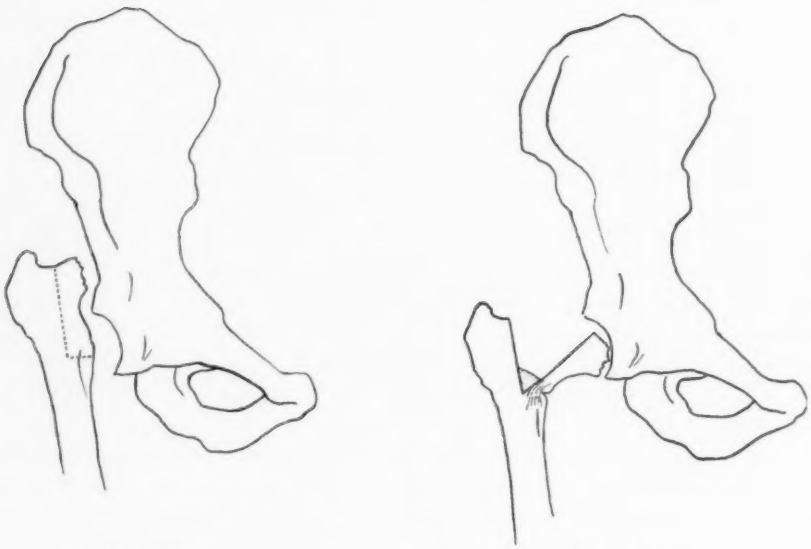


FIG. 1-A FIG. 1-B

Diagrammatic drawing of hip.
Fig. 1-A: Before operation.
Fig. 1-B: After operation.

the operation is completed, there is a triangular space left between the prongs of the fork. This triangular space eventually fills in with bone, so that the upper end of the femur is eventually a triangular mass of bone, with the upper inner point of the triangle lying within the acetabular cavity. This remains within the acetabulum, thereby preventing any upward displacement of the shaft. In the last case operated upon, the technique was modified by inserting a piece of fascia between the prongs of the fork. This resulted in the production of a true neck, which fitted in the acetabulum, instead of a triangular mass of bone at the upper end of the femur (Fig. 7).

The author believes that the point stressed by Whitman—the maintenance of the normal distance between the origin and insertion of the abductor muscles—is only an academic consideration, as the muscles, particularly in childhood, adapt themselves to the shortened distance resulting from the upward displacement of the femur, except in those very rare cases in which the upper end of the femur has slipped high on the ilium close to the origin of the gluteus medius muscle.

The operation described differs from Albee's bone-muscle-lever operation in that the greenstick fracture of the upper end of the femur is produced on the medial aspect of the femur rather than on the lateral aspect.

Before operating on such cases, we should, of course, try to bring the upper end of the femur to a position as nearly opposite the acetabular cavity as possible, using skin traction or even skeletal traction if necessary. It is also well before operating to have a roentgenogram taken of the hip with and without traction. If the hip comes down sufficiently

FIG. 2

FIG. 3

Fig. 2: Case 1. Before operation.

Fig. 3: Case 1. Over one year after operation, showing triangular formation of the upper end of the femur as described in the text, with the inner point of the triangle well in the hip socket.

with simple manual traction, nothing further is done, but, if it does not come down, then traction is applied to bring it down.

Dislocations of the type under consideration always follow an infection. Therefore, before we attempt to do any reconstructive work, we must be sure that there is no active disease present. However, the operation should be done as soon as possible after we are certain that there is no danger of lighting up any latent infection. The author waits until there is no clinical or roentgenographic evidence of activity before performing the fork operation. In one case the writer operated only nine months after the patient had recovered from acute suppurative arthritis. This seems rather early, but there were absolutely no signs of acute inflammation when the hip joint was opened.

The author believes that this operation should be kept in mind during the treatment of acute suppurative lesions of the hip in cases in which the head of the femur is absorbed. The patient should not be allowed to bear weight on the affected limb, in order to prevent the upper end of the femur from slipping upward. Walking, as soon as indicated, may be

FIG. 4

FIG. 5

Fig. 4: Case 3. Before operation.

Fig. 5: Case 3. Immediately after operation, showing the greenstick fracture of the upper inner end of the femur in the lower portion of the acetabulum. The wedge of bone between the two prongs of the upper end of the femur has shifted some, but the fork position is maintained.

Fig. 7

Case 4. Four months after operation. The child has been walking.

Fig. 6

Case 4. Before operation.

permitted with a Thomas extension brace on the affected side and a raised shoe on the good foot. If this procedure is followed, considerable shortening may be prevented and the later reconstructive operation will be less difficult technically.

The operation was first done for an ununited fracture of the neck of the femur in an elderly patient. The final result in that case was complete absorption of the medial prong of the fork, so that ultimately the patient was left with a flail hip and the operation was, therefore, a total failure. Why the fork absorbed the writer does not know, because it was composed essentially of part of the upper shaft of the femur. Fractures in this region usually unite rather readily. Because of this failure, and fearing a similar result, the writer has not attempted the fork operation again in treating this condition. The subsequent cases have all been pathological dislocations following acute suppurations of the hip, and absorption has not taken place in any of them. The operation is now restricted to this type of case,—pathological dislocation following acute suppuration of the hip in children.

REFERENCES

CAMPBELL, W. C.: Reconstruction Operations of the Hip Joint. Texas State J. Med., XXI, 555, 1926.

SPEED, J. S.: Reconstruction Operation on the Hip. J. Am. Med. Assn., LXXXVII, 1631, 1926.

EPIPHYSIOLYSIS OF THE UPPER FEMUR

A Report of Thirty-Eight Cases

BY WALTER SCOTT, M.D., SIOUX CITY, IOWA

*From the Orthopaedic Department *, State University of Iowa, Iowa City*

Epiphysiolysis of the upper femur is by no means a rare condition. At the time of puberty it seems to be the most common cause of hip-joint trouble and, compared with other hip diseases of youth, it holds fourth place in frequency according to the files of our Clinic:

Tuberculosis of the hip	269 cases
Suppurative conditions (osteomyelitis)	71 cases
Perthes' disease	100 cases
Epiphysiolysis	38 cases

Males are more frequently affected than females; in our material we have found the ratio to be twenty-seven to eleven. The average age incidence was twelve and two-tenths years for girls and thirteen and seven-tenths years for boys, which corresponds to the earlier puberty in the female.

Our material showed that constitutional symptoms (indicating anomalies or disorders in the endocrine system) were present in about one-half of the cases. Two constitutional or anatomical types were outstanding: the tall, slender type (six cases), and the rather short, obese type with the characteristic signs of Fröhlich's syndrome (ten cases, seven boys and three girls). In three cases there were signs of healed rickets (funnel chest). In seven cases there was a history of familial obesity.

One case is of special interest. The father of a tall boy with epiphysiolysis had similar but less marked symptoms during his adolescence and was treated with bed rest and physiotherapy. Recent roentgenograms of the father show a coxa vara, which is very likely the end result of an incomplete epiphysiolysis.

These facts point to a constitutional rather than to a traumatic cause. In only seven of our cases was the onset sudden; in the others, onset was insidious and the patients complained of intermittent pain in the hip. It is difficult to say just what pathological process is responsible for the lessened resistance at the epiphysiodiaphyseal junction, for actual pathological reports are few and inconclusive. We have seen in some of the roentgenograms irregularities of the juxta-epiphyseal zone suggestive of disturbed enchondral ossification. In one case (bilateral) we were able to demonstrate cystlike changes in the juxta-epiphyseal area, although the patient was clinically symptom-free at that time. (See Figure 1.) However, epiphysiolysis took place four months later.

* Service of Arthur Steindler, M.D.

TABLE I

ANALYSIS OF THIRTY-EIGHT CASES OF EPIPHYSIOLYSIS OF THE UPPER FEMUR

Case	Sex	Age at Onset (*Years*)	Constitutional Type	Familial Obesity	Side Injured	Degree of Trauma	Mode of Onset	Duration of Symptoms	Intermittent Pain	Treatment (Before or After Admission)	Clinical Result	Roentgenographic Findings
1. R. J.	Male	14	Tall		Left	Mild	Gradual	3 weeks	Yes	Manipulation and cast	Good	Early typical; later arthritis. (See Figures 2 and 3.)
2. D. B.	Male	13			Right	Severe	Sudden	2 years	No	None	Good	Compression fracture of epiphysis. Necrosis of head followed by reorganization. (See Figure 5.)
3. S. T.	Male	14	Funnel breast	Yes	Left	Severe	Gradual	1 year	Yes	Cast	Good	Partial displacement. Osteoporosis of juxta-epiphyseal area.
4. E. M.	Female	12	Fröhlich's syndrome	Yes	Right	Mild	Gradual	5 months	Yes	Manipulation and cast	Good	Typical picture.
5. L. H.	Male	11	Fröhlich's syndrome	Yes	Left	Mild	Gradual	2 years	Yes	Manipulation and cast	Good	Irregularities in juxta-epiphyseal area. Good reduction. Coxa vara followed.
6. E. D.	Male	13			Bilateral	None	Gradual	5 years	Yes	Physiotherapy	Poor	Arthritic changes with deformity.
7. G. R.	Male	15	Tall	Yes	Right	None	Gradual	9 months	No	Manipulation and cast; arthroplasty	Poor, ankylosis	Typical. Later, ankylosis and coxa vara.
8. E. J.	Female	14			Left	Mild	Gradual	4 months	Yes	Manipulation and cast	Too recent	Typical. Not a good reduction. Irregularities in juxta-epiphyseal area.
9. J. A.	Male	15			Right	Severe	?	20 years	?	Physiotherapy	Arthritis	Coxa vara and arthritis.
10. B. S.	Male	12	Fröhlich's syndrome		Left	Mild 2	Gradual	10 months	Yes	Manipulation and cast	Excellent	Moderate displacement. Good reduction.
11. R. P.	Male	14		Yes	Left	Mild	Gradual	1 year	Yes	Manipulation and cast	Poor	Typical. Good reduction. Coxa vara.
12. C. H.	Female	11			Right	Mild 2	Gradual	10 months	Yes	Cast	Excellent	Typical. Poor reduction. Coxa vara. Porosis of lower pole.
13. A. G.	Female	14			Right	Mild 2	Gradual	6 months	No	Manipulation and cast	Stiff	Typical. Irregularities in juxta-epiphyseal area. Good bony union.

													and cast		Typical. Irregularities in juxta-epiphyseal area. Good bony union.
14.	L. W.	Female	8	Fröhlich's syndrome		Right	Severe	Sudden	4 years	No	Open reduction	Good	Good reduction. Good bony union.
15.	C. L.	Male	14			Right	Severe	2 Gradual	18 months	?	Open reduction	Fair	Bony union. Coxa vara and arthritic changes.
16.	A. H.	Male	10	Fröhlich's syndrome		Right	Severe	Sudden	10 months	?	Manipulation and cast	Good	Typical. Aseptic necrosis of head. Premature synostosis. (See Figure 6.)
17.	M. W.	Male	12	Tall		Left	Mild	Gradual	2 years	Yes	Osteotomy	In cast	Healed in poor position. Marked arthritic changes.
18.	W. H.	Male	15			Left	None	Gradual	6 weeks	Yes	Manipulation and cast	In cast	Slight displacement. Aseptic necrosis of head. (See Figure 7.)
19.	T. H.	Female	10	Fröhlich's syndrome	Yes	Bilateral	Mild	Sudden	1 year	?	Manipulation and cast	Good	Slight displacement. Rough juxta-epiphyseal area. (See Figure 1.)
20.	R. C.	Male	15			Right	None	Gradual	10 months	Yes		?	Loss of "S" shape. Marked softening in juxta-epiphyseal area. Coxa vara.
21.	E. D.	Male	12	Fröhlich's syndrome		Right	None	Gradual	1 year	Yes	Casts	?	Incomplete lesion. Softening in juxta-epiphyseal area. Complete resolution in 7 months.
22.	L. D.	Male	15		Yes	Left	Mild	Gradual	2 weeks	?	Manipulation and cast	Excellent	Irregularities in juxta-epiphyseal area. Early occlusion later.
23.	V. H.	Male	13	Fröhlich's syndrome		Bilateral	None	Gradual	2 years	Yes	Manipulation and cast	Good	Bilateral coxa vara with arthritis on one side.
24.	R. E.	Male	16			Right	Mild	Gradual	?	Yes	Manipulation and cast	?	Typical. Irregularities in juxta-epiphyseal area.
25.	H. P.	Male	15	Funnel breast		Bilateral	Severe	Sudden	4 years	No	Osteotomy	In cast	Marked deformities and arthritis.
26.	S. S.	Female	11			Right	Mild	2 Gradual	3 months	Yes	Manipulation and cast	Good	Slight coxa vara and irregularities in structure of upper and lower poles.

TABLE I (*Continued*)

Case	Sex	Age at Onset (*Years*)	Constitutional Type	Familial Obesity	Side Injured	Degree of Trauma	Mode of Onset	Duration of Symptoms	Intermittent Pain	Treatment (Before or After Admission)	Clinical Result	Roentgenographic Findings
27. E. R.	Female	14			Bilateral	None	Gradual	?	Yes	Manipulation and cast	Fair	Irregularities in juxta-epiphyseal area on one side.
28. A. K.	Male	13	Tall		Right	Mild	Gradual	6 months	Yes	Open reduction and peg	Good	Irregularities in juxta-epiphyseal area. Good bony union and premature occlusion typical.
29. F. S.	Female	13			Left	None	Gradual	?	Yes	None	?	Typical.
30. P. H.	Female	15			Left	None	Gradual	43 years	Yes	None	Arthritis	Marked arthritis. Sclerosis in weight-bearing portions. Slight displacement.
31. R. E.	Male	15	Funnel breast, tall		Left	None	Gradual	4 months	Yes	Cast. To have open reductions	Poor	Typical. Resorption of neck.
32. R. E.	Male	14			Left	Mild	?	26 years	?	Bed rest	Good	Coxa vara and coxa plana.
33. C. B.	Male	11	Fröhlich's syndrome		Bilateral	Mild	Gradual	15 months	No	Manipulation and cast	Too recent	Some osteo-arthritis and irregularities in juxta-epiphyseal area. (See Figure 4.)
34. R. N.	Male	14	Tall		Left	Mild	Gradual	18 months	Yes	Traction; spica for 5 weeks	Fair	Typical and incomplete.
35. C. C.	Male	14			Left	Mild	Gradual	3 years	Yes	Late attempt at manipulation	Poor	Typical picture of a non-reduced epiphysiolysis.
36. P. H.	Female	11		Yes	Right	None	Gradual	18 months	Yes	Physiotherapy and bed rest	Poor	Typical picture of a non-reduced epiphysiolysis.
37. W. H.	Male	16	Fröhlich's syndrome		Bilateral	None	Gradual	7 months	Yes	None	Poor	Typical picture of a non-reduced epiphysiolysis.
38. D. W.	Male	15			Left	None		8 months	Yes	Manipulation and cast	Too recent	Typical picture of a non-reduced epiphysiolysis.

FIG. 1

T. H., female, aged ten. Slight displacement of the right femoral head downward and backward. The left side shows some irregularity in the juxta-epiphyseal portion in the femoral neck. Epiphysiolysis occurred on the left side four months after this roentgenogram was taken.

Enchondral ossification is largely dependent upon the function of the sex glands and hypophysis, for many cases point to a disordered function of these glands. But, if there be a central cause for this abnormal ossification, one should expect to find the same basic pathology in all of the epiphyseal plates. However, it is only the upper epiphyseal discs of the femora that become affected clinically.

The onset of the disease and the relatively high percentage in boys show that epiphysiolysis has probably nothing in common with Perthes' disease, although this also develops on a strongly constitutional basis.

FIG. 2

R. J., male, aged fourteen. Downward and backward rotation of the proximal fragment. The distal fragment is dislocated upward and is almost touching the outer edge of the acetabulum. There is marked outward rotation.

FIG. 3

R. J. One year later than Fig. 2. The lateral pole appears compressed and there is slight lateral subluxation of the head. The bony structure of the epiphysis is irregular and osteosclerotic changes are pronounced. Note the two subchondral cystlike foci of osteoporosis.

Perthes' disease occurs at the ages of from five to seven and the incidence is by far greater in boys.

The typical roentgenogram, showing the downward and backward rotation of the proximal fragment, is well known. (See Figure 2.) As already pointed out, the earlier stages with incomplete displacement may show irregularities in the juxta-epiphyseal portion of the femoral neck (Figs. 1 and 4).

In a typical case of epiphysiolysis one may assume that the periosteum of the neck remains practically intact, and that the vascular supply of the upper fragment is not disturbed. Aseptic necrosis of the upper fragment is an unusual feature and, as far as we know, has not yet been described in this group of non-traumatic epiphysiolyses. (See Figures 5, 6 and 7.) Careful examination of the roentgenograms of our cases, however, shows that in five of them aseptic necrosis was present, as evidenced by a dense shadow in the upper fragment.

Follow-up roentgenographic examinations showed the gradual resorption of the necrotic proximal fragment. The upper portion of the femoral head, just below that part of the joint surface which after the displacement of the epiphysis has to bear the body weight, is the last part to become reorganized. This is a point which, in a later stage of the disease (especially if only one roentgenogram is available), makes it difficult to decide whether this dark shadow is a relic of aseptic necrosis or whether it is a reactive sclerosis, due to static stress of weight-bearing. Serial roentgenograms helped to exclude these diagnostic difficulties.

It is interesting that, even though aseptic necrosis of the proximal fragment occurs, reorganization leads to a complete restitution in a relatively short time and without marked alteration in shape. Only in one case did perfect restitution of the head fail to take place. In this case the

FIG. 4

C. B., male, aged twelve. The changes on the left side indicate an older process. There is distinct evidence of irregularities in the juxta-epiphyseal portions of the necks. The heads show little or no reaction, while the distal fragments, especially that on the left side, show external rotation and anteversion together with some upward displacement.

apex of the head remained separated from the remaining organized tissue by an irregular porotic zone of demarcation. The bone structure of the non-reorganized apex was very dense and the picture was similar to that of osteochondritis dissecans. These few cases of epiphysiolysis, followed by necrosis of the femoral head, are likely to lead to subsequent disturbing changes. This has recently become more widely known, especially in traumatic fractures of the femoral neck in youth.

FIG. 5

D. B., male, aged fifteen. Flattening of the femoral head and marked porosis of its lateral pole. Note the wedge-shaped porotic area at the apex of the head containing a sclerotic fragment and surrounded by osteosclerotic tissue. The epiphyseal plate is indistinct.

The type of treatment is usually dependent upon the stage of the disease. Closed measures, especially Whitman's manipulation as modified by Leadbetter, are likely to be successful in an early stage. In later stages, when the displaced head is already in fibrous union with the femoral neck, forced manipulation can lead only rarely to a satisfactory result. This was true in our series. Our impression is that the position of the femoral head in this situation remains essentially the same and that the tearing of fibrous adhesions (which is followed by newly formed scar tissue) causes an increase in the

FIG. 6

A. H., male, aged eleven. The medial lower pole and lateral upper pole are extremely porotic. The central portion shows a more or less wedge-shaped area of aseptic necrosis which has not yet undergone reorganization.

FIG. 7

W. H., male, aged fifteen. The dark area of aseptic necrosis is undergoing rapid reorganization from the central portion and from the lateral pole. The joint space is narrowed.

arthritic symptoms. Therefore, we believe that in the later stages of epiphysiolysis open methods are indicated.

Open reduction was performed in three of our cases. In one of these an ivory peg was used to keep the fragments in the corrected position. Results were good in two cases (in the first, no arthritis, good motion, no pain; in the second, no pain, slight limp, flexion to 20 degrees) and in one case poor (ankylosis of the hip; 50 per cent. disability for all kinds of labor).

An arthroplasty of the hip was performed in one case, but bony union followed in good position allowing good symptomless locomotion.

The simplest procedure in older cases is osteotomy to correct deformity and to improve weight-bearing. The subtrochanteric type was done in two instances.

Inveterate cases were given physiotherapy and immobilization in plaster casts, until all arthritic symptoms were alleviated.

THE THERAPEUTIC ACTIVE PRINCIPLE OF MAGGOTS

With a Description of Its Clinical Application in 567 Cases

BY S. K. LIVINGSTON, M.D., F.A.C.S., HINES, ILLINOIS

Considerable reference has been made in the literature during the past few years to growth-stimulating substances [3, 4, 5, 6, 7]. The introduction of maggot therapy in the treatment of chronic osteomyelitis, with its attendant therapeutic-principle theory, has revived the search for such a substance.

Before the World War, chronic osteomyelitis was variously treated. The problem of stimulating granulation tissue to fill the resulting bone and soft-tissue cavities gave rise to the development of various pastes and semisolid substances. Following the War, standardized methods of treatment were evolved,—namely, the Carrel-Dakin method, the Orr technique, and Baer's maggot therapy. These procedures, with their several modifications, are now in general use.

If we pause for a moment to consider the factors underlying chronic osteomyelitis, we have, in the first place, disseminated foci of infection and devitalized particles of bone and medullary tissue, enclosed in rigid-walled cavities throughout the bone. To eliminate these foci, surgery is necessary.

After elimination of foci by operative interference, one is confronted by a large cavity which must be filled by granulation tissue. Therefore, the second factor underlying the affection is the difficulty encountered in obtaining satisfactory healing of this cavity by granulation. The magnitude of this difficulty is appreciated when we realize that bone defects, unless stimulated, heal so slowly that the early formed granulations undergo the changes incident to scar-tissue formation before the bone cavity becomes entirely filled. It is, therefore, evident that, as cicatrization occurs in the periphery, there is a consequent depletion in blood supply which prevents further bone growth and complete healing. One is, therefore, confronted with well-formed scar tissue at the periphery and a cessation of healing in the center.

In view of these considerations, it is evident that the ideal method of treatment for chronic osteomyelitis should have as its basis the following requisites:

1. Thorough surgical removal of diseased parts.
2. Some efficient method of sterilization of the surgically formed wound.
3. Some method of removal of the wound discharges and sloughed tissue that occur subsequent to operation.
4. Some agent that will produce uniform and rapid growth from the bottom, to cause complete filling of the cavity before circulatory changes, incident to scar formation, occur.

With these criteria in mind, it is now opportune to examine the effects of the various methods of treatment mentioned. The Carrel-Dakin, the Orr, and the maggot therapies are all based upon a thorough saucerization of the affected part,—that is, a surgical procedure to remove all devitalized bone, overhanging ledges, and grossly infected soft tissues. Beyond that, the underlying principles are different.

At the time of the introduction of the Carrel-Dakin method, it was thought that the efficacy of the treatment was due to chemical sterilization of the wound. This was subsequently disproved, for inert solutions such as physiological saline, used with the same minute technique, produced the same results. It became evident, therefore, that the value of the treatment lay in the physical removal and possibly the chemical solution of the wound discharges. This method, however, meets only two of the four criteria proposed for the ideal method of approach to the treatment of chronic osteomyelitis,—namely, the thorough surgical removal of all diseased parts and the mechanical and chemical removal of wound slough and discharges.

The Orr technique is based upon a thorough surgical removal of all diseased parts. The vaselin pack acts as an efficient method of drainage. In addition, the physical resistance offered by the pack and the physiological rest incidental to immobilization in plaster-of-Paris aid wound healing which must be spontaneous, for there is no active agent to stimulate growth. The infrequent dressings prevent reinfection, but no efficiently active measure is introduced to sterilize the wound or to stimulate repair. Subsequent to the introduction of the method, it was realized that, in accordance with the experiments and theories of D'Herelle and Besredka, spontaneous sterilization occurs through the formation of bacteriophages. More recently, Albee has added to this method by attempting to sterilize the wound by the administration of a stock or an autogenous bacteriophage. This method, therefore, meets all of the criteria save the last—stimulation of growth—for which no provision is made.

Maggot therapy meets all of the criteria. First, there is a thorough surgical removal of the diseased area; second, the wound is actively sterilized by the maggots which physically remove micro-organisms by ingestion; third, the proteolytic activity of the maggot enzymes breaks down the wound discharges and sloughs into end products, which are then consumed by the maggots; and fourth, the therapeutic active principle of maggots stimulates rapid growth. The isolation, development, standardization, and clinical use of this active principle has resulted in the production of a needed clinical growth-stimulating substance, which has been used by the author in 567 cases of chronic osteomyelitis, chronic leg ulcers, compound fractures, and other similar suppurative lesions.

It was formerly supposed that maggots were effective because of: their mechanical action, rapid movement, and the ingestion and digestion of bacteria and necrotic material, which render such matter inert; stimu-

lation of a rapid outpouring of blood serum, which is healing; and the rapid increase of the pH of the wound. Under close observation, it has been noted that, in the early stages of treatment (after the first to third applications), the maggots live until replaced. As the treatment continues, the maggots live for a decreasing period, and, after the fifth application, the maggots live only a few hours. Death occurs because the pH of the wound has increased and because some substance has been produced through the contact of the live maggots with the tissues which so increases in virulence that, with time, it kills the maggots by its potency. For want of a better name, we have called this substance a therapeutic active principle.

All through this work our attention has been continually focused on the fact that it was not mere mechanical action of the maggots that was primarily responsible for the beneficient results obtained by their use. Animal experiments showed that this additional agent which was developed through the contact of the maggots with the living tissues was, in itself, a curative agent. That an additional agent was responsible for effecting a cure seemed clearly demonstrated by the use of filtered extracts from the bodies of crushed larvae. These observations pointed to the presence of some substance which, in itself, was sufficiently powerful to overcome infections and to permit a normal pH balance to be established. Our opinion was further warranted from the fact that filtered, uncontaminated products derived from the bodies of larvae in culture, when brought into contact with pyogenic organisms in petri dishes, attenuated the cultures.

The factors which determine the efficacy and success of any postoperative treatment consist of:

1. The removal of all sources from which continuing or repeated reinfection can take place.
2. Rigid attention to postoperative detail.
3. Intimate contact between the infected surface and the medium used.

In cases of osteomyelitis, complete removal of all sources from which continuing or repeated reinfection can take place is possible in only a very small percentage of cases in which a shallow localization of the process has occurred. Only in these cases which result in a shallow, wide wound after operation, into which antiseptic solution can be adequately instilled, can the Carrel-Dakin or bipp treatment be successful.

Because of the lack of recognizable characteristics, it is frequently impossible to remove completely the diseased tissue, to guard against the formation of subsequent sequestra, to remove entirely all infected thrombi, or to prevent or to control blood infections—all of which are potent and potential causes for the continued reinfection of the wound. To overcome these difficulties Orr recommends a vaselin pack and Baer recommended maggots.

ORR METHOD OF TREATMENT

In a large number of cases, after the requisite thorough osteotomy, the wound was packed wide open with vaselin gauze, according to the method of Orr, and allowed to granulate under the pack until the surface was very healthy looking to the naked eye. This was followed in some cases by a strapping together of the lips of the wound with adhesive which was left undisturbed for from seven to ten days. At the end of that time it was found that complete healing had taken place in some cases. Smears taken from these wounds at the time of the strapping showed that organisms were present; in many of the wounds, the number of organisms exceeded that accepted as the orthodox minimum for the secondary closure. In many of these cases, treated by Orr's method, healing takes place at either pole of the wound with the persistence of a small sinus near the center. On the other hand, the retention of even a few bacteria, as determined by smears, accounts for the persistence of the sinus, or for a recurrence in a certain number of these cases. For the bacteria, few though they may be, when encysted in the tissues of the wound, are liable under the proper stimulus to assume a renewed activity and to cause a subsequent suppuration and reopening of the wound or a failure of closure of the sinus. In children the Orr method of treatment was successful in a higher percentage of cases than in adults.

Under these conditions, it behooves one to take cognizance of the sources of failure which are inherent because of the nature of the disease process in a tissue as peculiar as bone.

MAGGOT THERAPY

In a previous part of this discussion it was indicated that, because of lack of recognizable characteristics, it is frequently impossible to remove completely the diseased bone at the time of operation, to guard against the subsequent formation of sequestra or necrosis, or to remove completely all infected thrombi,—all of which play important rôles in the continued reinfection of the wound. By the employment of maggot therapy—which consists in (1) living maggots, (2) maggot active principle, and (3) a combination of these accompanied by autogenous vaccine given postoperatively—the operative procedure is continued,—that is, the work of the surgeon is supplemented. The small microscopic areas of infection which it is impossible to see at the time of operation are subsequently and continuously removed, thereby decreasing the potential causes of a continued or subsequent reinfection of the wound. Maggots are living antiseptics and they are especially useful in the large percentage of cases in which a molecular necrosis takes place.

Maggot Active Principle

Maggot active principle, derived from maggots of the *Lucilia sericata*, is a growth-stimulating substance. It is not simply a combina-

tion of picric acid and calcium carbonate to form calcium picrate, as described by Stewart, nor allantoin, as described by Robinson. This has been proved by clinical trial, and can be understood better when we realize that maggots are fly embryos and, therefore, of necessity are rich in complex organic substances which, because of their embryonic nature, are growth stimulating. Maggot extract can be considered best as a complex radical composed of organic embryonic substances, calcium carbonate, allantoin, and the sulphydryl radical. A review of the literature on any one of these substances will reveal growth-stimulating properties; therefore it is understood how these substances, when introduced in combination into a wound, would bring about growth stimulation.

Vaccine Therapy

In association with maggot therapy, because of the large percentage of cases which are hematogenous, a course of vaccine therapy is administered. This consists of polyvalent vaccine of pyogenic organisms suspended in the maggot active principle as a vehicle. The vaccine is administered every fourth day intramuscularly in doses varying from one-tenth of a cubic centimeter to one cubic centimeter, unless untoward effects are observed.

End Results

Of the 567 patients treated by maggot therapy, 88 per cent. were improved and were discharged from the hospital without discharging sinuses. The cavities were completely filled with pink, healthy granulation tissue. This degree of success was 38 per cent. higher than in control cases treated by other methods. The period of healing and convalescence was also shorter when the maggot method of treatment was used.

No method of treatment, however, has seemed to give any assurance that a recurrence of the bone lesion will not subsequently take place. The healing of any bone wound is beset by many opportunities for the retention of dormant foci of infection or small septic sequestra, or by other factors which are always capable, under the proper stimulus and environment, of causing secondary inflammatory reaction in the neighborhood of the original wound. However, the maggot method of therapy offers the least possibility or opportunity for the conditions which cause a recurrence to take place subsequently.

CONCLUSION

In the treatment of chronic osteomyelitis, compound fractures, chronic leg ulcers, and similar pyogenic infections, maggot therapy—consisting of living maggots, maggot extract, or the combination of these—has proved 38 per cent. more effective than other forms of treatment.

BIBLIOGRAPHY

1. Baer, W. S.: Sacro-Iliac Joint; Arthritis Deformans; Viable Antiseptic in Chronic Osteomyelitis. Proc. Internat. Assembly, Inter-State Post-Grad. Med. Assn. North America (1929), V, 371, 1930.

Baer, W. S.: The Treatment of Chronic Osteomyelitis with the Maggot (Larva of the Blow Fly). J. Bone and Joint Surg., XIII, 438, July 1931.

2. Fabre, J. H.: Souvenirs entomologiques. Vol. X, p. 275. Paris, 1924.
3. Hammett, F. S.: The Natural Chemical Equilibrium Regulative of Growth by Increase in Cell Number. Protoplasma, XI, 382, 1930.
4. Livingston, S. K.: Maggots in the Treatment of Chronic Osteomyelitis, Infected Wounds, and Compound Fractures. An Analysis Based on the Treatment of One Hundred Cases with a Preliminary Report on the Isolation and Use of the Active Principle. Surg. Gynec. Obstet., LIV, 702, 1932.
5. Livingston, S. K., and Prince, L. H.: The Treatment of Chronic Osteomyelitis with Special Reference to the Use of the Maggot Active Principle. J. Am. Med. Assn., XCVIII, 1143, 1932.
6. Robinson, William: Stimulation of Healing in Non-Healing Wounds by Allantoin Occurring in Maggot Secretions and of Wide Biological Distribution. J. Bone and Joint Surg., XVII, 267, Apr. 1935.
7. Stewart, M. A.: A New Treatment of Osteomyelitis. Preliminary Report. Surg. Gynec. Obstet., LVIII, 155, 1934.

FRACTURES OF THE SUPRACONDYLAR PROCESS OF THE HUMERUS

BY CLARMONT PAUL DOANE, M.D., FRESNO, CALIFORNIA

*From the General Hospital of Fresno County**

Of considerable interest from the anthropological viewpoint have been the incidence and racial distribution of the supracondylar variation in human beings. For a number of years Terry and his associates [1,2,3,6] have been studying the occurrence of the supracondylar process in various races and social strata.

The supracondylar process is a bony projection, of variable size, which is found about two inches above the medial epicondyle of the humerus. It springs from the medial surface of the shaft, near the anterior margin, and is directed downward, forward, and medially toward the medial epicondyle. It is joined to the medial epicondyle by a band of fibrous tissue.

Through the ring formed by the fibrous band which joins the supracondylar process with the medial epicondyle pass the brachial artery and median nerve. In some cases only the nerve is found within it. This ring corresponds to the supracondylar foramen of lower animals. Terry [5] states that this process gives rise to the pronator teres, and occasionally affords insertion to a persistent lower part of the coracobrachialis.

The incidence of the supracondylar process of the humerus is very low. The percentage of incidence, as given by different authors, varies. Terry [3] has given the incidence in the white race as 1 per cent., while other authors give from 0.6 per cent. to 2.7 per cent.

The purpose of this paper is to call attention to this vestigial structure from a clinical standpoint. Because it is rare, many clinicians are not aware of its occasional presence, and, when it is encountered, it is not recognized. It is frequently regarded as a pathological condition of the bone rather than as a normal anatomical variation.

When the process is long, it may easily be fractured and give rise to a great deal of pain. The palpation of a tender, bony projection on the medial aspect of the humerus, just above the elbow, should strongly suggest the presence of a fractured supracondylar process rather than an avulsion of a portion of the shaft. The palpation of such a structure some time after the history of injury should not suggest an old fracture of the humerus with exuberant callus formation, nor should it be termed an "exostosis".

In order to ascertain whether or not this process is present, the examination should be conducted as follows. The patient should be seated

* Service of D. I. Aller, M.D.

facing the examiner with arms bared. With the fingers of one hand, the examiner palpates the lower half of the shaft of the humerus; with the other hand, he holds the patient's wrist and moves the forearm passively to secure optimum relaxation of the muscles of the arm. The anterior aspect of the lower fourth of the humerus and the medial epicondylar ridge should be explored during each examination.[3]

Roentgenologists rarely demonstrate the presence of the process in routine views of the humerus, because when ordinary plates are taken the process is usually not in profile. When the process is suspected, a slightly oblique view puts it into sharp profile. Often a second view is necessary to verify the findings in the first.[8]

If there has been an injury to the process, and it is causing marked pain, the treatment is removal. This is accomplished very simply by making a short incision directly over the process and by exposing it down to the shaft of the humerus, where it may be either cut or broken off and the base smoothed. Care must be taken not to injure the brachial artery or the median nerve, which lie close to the base of the process. These structures are easily retracted and protected.

The following cases are reported in the hope that they may help others to identify fractures of this process.

CASE 1. The first case seen by the author was that of a Mexican female, thirty-eight years of age. She was a transient and had suffered a compound fracture of the nose and a fractured left clavicle in an automobile accident. In making his examination, the admitting physician noted the recent injuries. In addition, he palpated a bony mass on the inner aspect of the left humerus, just above the elbow. The patient stated that she had been injured there a few years previously, but had had no pain in that region since that time. Roentgenograms showed an elevation on the inner aspect of the humerus, about two inches above the elbow. A tentative diagnosis of healed fracture of the distal third of the left humerus was made. The patient was seen on the ward and examination revealed a supracondylar process. Further roentgenograms brought into profile a long supracondylar process (Fig. 1). The process showed definite rotation, which would indicate that the previous injury described by the patient was undoubtedly a fracture of this process. Other members of the patient's family were unavailable for examination to determine the factor of heredity.

FIG. 1

Case 1. Roentgenogram showing healed fracture of the supracondylar process, with rotation.

That this variation was found in a Mexican, who is a hybrid Indian-white, is of interest, for the structure is exceedingly rare in the colored races.[8]

CASE 2. The second case seen by the author was that of a fifteen-year-old white male. He was a high-school athlete and had been having considerable pain whenever the inner aspect of the left humerus was struck. Friction against the body was painful. Five years prior to admission, he had been struck on the left arm, and had had considerable pain at the time. It was then that a bony projection on the inner aspect of the left humerus was first noticed. Recently, the protrusion had again become extremely painful. His family physician sent him to the writer with the diagnosis of "bony exostosis" of the left humerus. The presence of a supracondylar process was easily determined by palpation, for the process was unusually long. Because palpation was very painful, the diagnosis of fracture was made. Roentgenograms showed in profile a long supracondylar process, with a definite fracture line visible just beyond the midpoint. Callus formation could be clearly seen (Fig. 2). At operation, a ribbon-like supracondylar process, two and seven-tenths centimeters long, was removed. At the junction of the outer and middle thirds was an imperfectly healed fracture, with excess callus formation. Other members of this patient's family were examined, but no trace of the process could be found in them.

FIG. 2

Case 2. Roentgenogram showing a long supracondylar process with a definite fracture line visible just beyond the midpoint. Note callus formation.

SUMMARY

The incidence of the supracondylar variation in the white race is about 1 per cent.

Clinicians are apt not to be aware of its occasional presence, and hence fail to diagnose injuries to the process.

Treatment for painful fractures is removal of the process.

REFERENCES

1. CADY, L. D.: The Incidence of the Supracondyloid Process in the Insane. Am. J. Phys. Anthrop., V, 35, 1922.
2. CADY, L. D., AND FRANCIS, B. F.: The Supracondyloid Process in the Feeble-Minded. Am. J. Phys. Anthrop., X, 387, 1927.
3. TERRY, R. J.: A Study of the Supracondyloid Process in the Living. Am. J. Phys. Anthrop., IV, 129, 1921.
4. TERRY, R. J.: Parallelism of Variation in a Mammalian Series. Anat. Record, XXVI, 171, 1923.
5. TERRY, R. J.: *In* Morris's Human Anatomy; a Complete Systematic Treatise by English and American Authors. Edited by C. M. Jackson. Ed. 8, Sect. III, pp. 194–195. Philadelphia, P. Blakiston's Sons & Co., 1925.
6. TERRY, R. J.: New Data on the Incidence of the Supracondyloid Variation. Am. J. Phys. Anthrop., IX, 265, 1926.
7. TERRY, R. J.: On the Racial Distribution of the Supracondyloid Variation. Am. J. Phys. Anthrop., XIV, 459, 1930.
8. TERRY, R. J.: Personal communication.

TURNBUCKLE BRACE

A Three-Point-Pressure Brace for the Corrective Treatment of Ambulatory Cases of Scoliosis

BY JOSEPH S. BARR, M.D., AND KARL BUSCHENFELDT, BOSTON, MASSACHUSETTS

From the Scoliosis Clinic of the Massachusetts General Hospital

There is in any orthopaedic clinic a certain group of patients with scoliosis whose spines are so flexible that at least partial correction of the curves can be obtained by manual pressure on the ribs and pelvis. Apparatus is desirable which can maintain that correction and also allow the patient to be ambulatory. Many devices have been used. Schanz has described a great variety of braces and corsets. The Brewster turnbuckle jacket, the butterfly brace, the Chambers brace, and some form of the Abbott jacket are the chief types of apparatus used today which make some effort at correction of deformity.

If such an apparatus is to be generally useful, it should conform to the following requirements: It should be comfortable. It should not unduly restrict the respiratory excursion of the ribs or limit hip motion. It should be constructed so that it may be easily put on and adjusted either by the patient or by the attendant. It should not require too frequent repairs or complete change because of the growth of the patient.

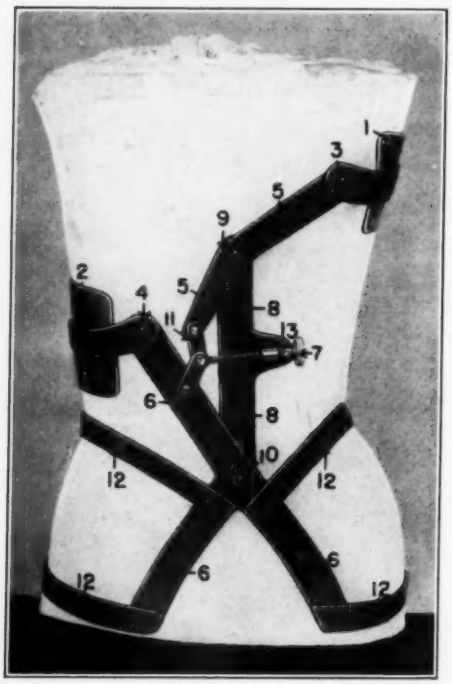


FIG. 1

Showing the brace outlined on the torso as viewed from the back. This brace was designed for the patient shown in Figs. 4, 5, and 6.

If such an apparatus is to be efficient in the correction of the scoliosis, it should fit snugly over the pelvis and iliac crests, these structures being used as the foundation from which the brace derives its lift. This is most important. No brace can efficiently correct scoliosis if it is not prevented from slipping by its firm grasp on the pelvis. In addition, the corrective force applied to the ribs should be easily adjustable and should be ap-

plied in two directions.

The brace shown in Figures 1, 2, and 3 seems to fulfil these requirements most satisfactorily. Since August 1935, thirty-three such braces have been made. In no instance has the use of the brace failed to obtain as much correction of the curvature as could be secured manually. Patients who have worn other types of apparatus previously state that this brace is more comfortable. The physicians who have seen the brace in use have been pleased with its simplicity and its effectiveness. The three corrective forces are applied by tightening one screw which exerts pressure on the ribs and pelvis in the directions which are most effective in the correction of the curves. The amount of correction is immediately observable clinically. The changes in the rib rotation, curvature of the spine, and elevation of the shoulders are not masked by the apparatus. The amount of correction can also be checked by roentgenograms taken with the patient in the standing position with the brace on.

FIG. 2

Right side of the torso, showing the fitting of the pelvic piece and the upper pressure pad.

FIG. 3

Torso as viewed from the left, showing the lower pressure pad fitted to the ribs.

Figure 1 shows the brace as viewed from the back before being covered with leather. This particular brace was built to correct a left dorsolumbar scoliosis. By tightening the screw (*7*), pressure is transmitted to the torso at three points:

1. The upper chest pad (*1*), which fits immediately below the shoulder, moves *upward* and inward, tending to lift the shoulder and to exert pressure inward and slightly backward on the upper ribs.

2. The lower chest pad (*2*) moves inward and forward against the posteriorly rotated ribs.

3. The right iliac crest is pushed downward through pressure exerted in that direction by the pelvic piece (*12*).

It is thus evident that correction of the curve is obtained by means of a free upward lift on the concave side and an inward and forward pressure on the convex side of the curve at its apex.

The brace is constructed as follows.* A plaster-of-Paris model is

* The pelvic steels are made of 18-gauge spring steel. The other steels are 15-gauge with the chest pads (*1* and *2*) made of 18-gauge aluminum reenforced with 15-gauge spring steel. The turn nut is made of brass, and the screw is of 10/32-gauge Bessemer steel.

made with the patient standing; the curves are partially corrected by traction with a head sling. Particular attention is paid to outlining the iliac crests. The wrapped model is filled with plaster and a torso is thus made. The torso is smoothed down. A leather pelvic girdle is then strapped on the torso and allowed to dry. It extends from about the level of the umbilicus to the symphysis pubis. The brace is then outlined on the torso. The Y-shaped arm (*6*) is placed first and then the pelvic steels (*12*) are fitted so that they come about one inch in front of the anterior-superior spines. *If any pressure comes on the spines, the brace is uncomfortable* and has not been made properly.

The optimal points for pressure on the chest have been determined by examination of the patient. The lower pad (*2*) is fitted to the torso and is attached to the arm (*6*) through the free joint (*4*). The toggle bar (*8*) is then fitted. Its upper end comes to the level of the seventh or eighth dorsal vertebra. The lower end of the toggle bar is attached to the

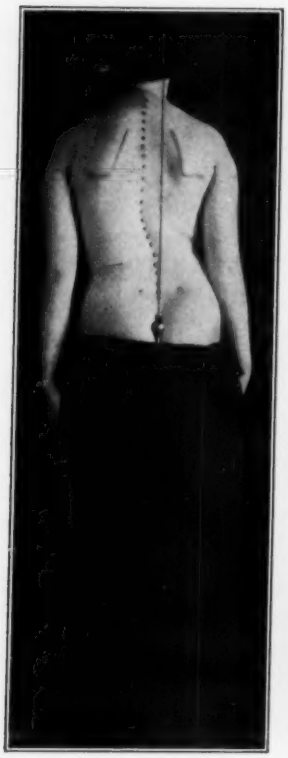


FIG. 4

Case 1. Patient with a left total scoliosis. The spinous processes have been outlined. The amount of list of the trunk is indicated by the suspended plumb-bob.

FIG. 5

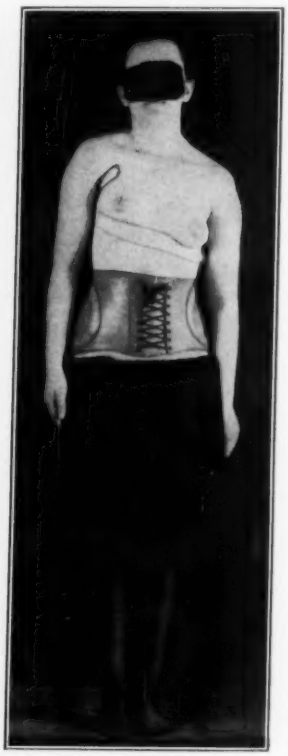


FIG. 6

Showing the amount of correction obtained by the brace. Note the secure fit of the pelvic piece on the iliac crests and the complete freedom of the chest. By abdominal restraint, the brace encourages "chest breathing" and self-correction of the chest deformity.

Y piece (*6*) at the level of the lumbosacral junction by the free joint (*10*). The center of motion is the point at which the turn screw crosses the toggle bar (*8*) and should be located at a little below the apex of the curve.

The upper pressure pad (*1*) is then applied. It is shaped so that its upper and anterior part will act as a crutch under the axilla. The crutch has in effect the tendency to pull the shoulder well back. The upper lever arm (*5*) is joined to the upper pressure pad (*1*) through the free joint (*3*) and is attached to the toggle bar (*8*) by the free joint (*9*). The screw (*7*) pulls through the swivelled collar (*13*) which is attached to the toggle bar (*8*). The pull is transmitted to the lever arms (*5* and *6*) by the joint (*11*).

FIG. 7

Case 2. Patient with a right-dorsal left-lumbar structural scoliosis.

FIG. 8

Case 2. Showing the amount of correction obtained by the brace. Note the downward thrust on the left iliac crest and the upward thrust beneath the left axilla, with resultant widening of the intercostal spaces and filling out of the sulcus between the ribs and pelvis.

The pressure pads are covered with leather or chamois. The brace is then sewed on to the leather pelvic girdle. A leather strap connects the upper and lower pads across the chest.

It will be noted that the toggle bar, freely jointed at both ends, remains fixed in position and *does not move* when the screw is tightened.

The relative lengths of the lever arms (*5* and *6*), as well as the ratio of leverage on each arm, are varied to meet the specific indications for the case in question.

The brace has been found to be particularly valuable in the correction of the pelvic tilt and scoliosis resulting from imbalance of the trunk muscles in infantile paralysis. The single flexible curve of a functional scoliosis is equally satisfactorily corrected. Certain cases of structural scoliosis with double curves can be benefited by the use of this brace if the curves are flexible.

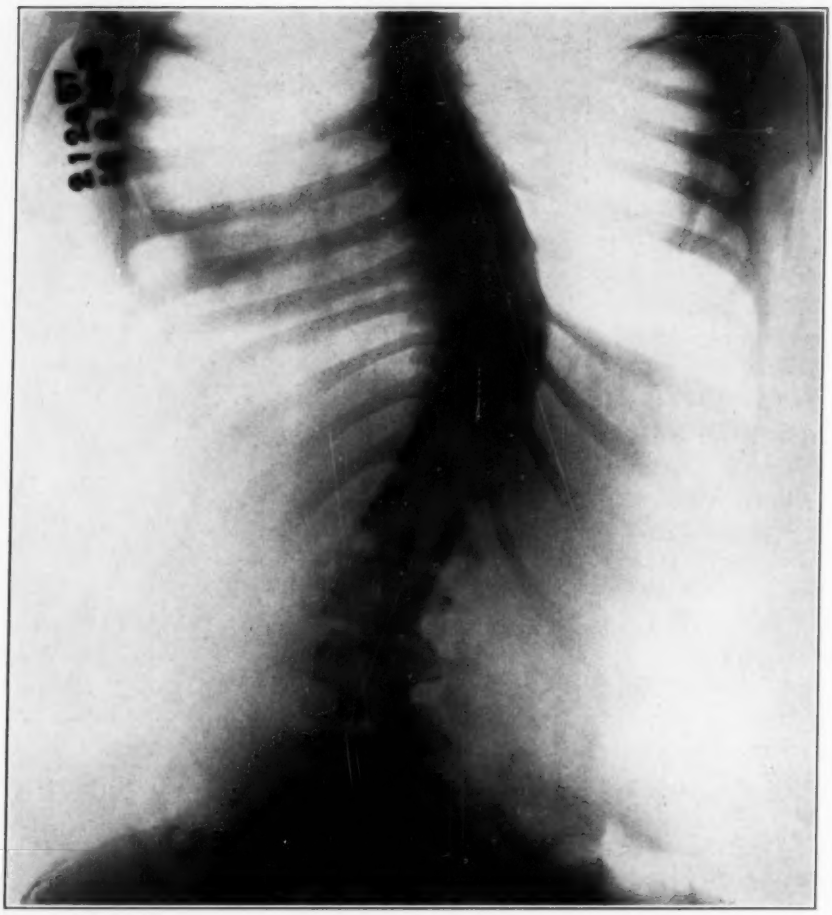


FIG. 9

Case 2. Roentgenogram taken with the patient in the standing position.

SUMMARY

The comfortable brace which has been described applies effective three-point pressure for the correction of spinal scoliosis. It does not unduly restrain the patient. Chest expansion is not restricted. The corrective force is obtained by tightening only one screw which is permanently attached to the brace and which transmits the force to the chest and pelvis by a very powerful leverage through a toggle bar. This brace is most effective in the correction of single flexible curves, but it is also applicable in certain cases of structural double curves which are not fixed. Operative procedure and exercises are not supplanted, but supplemented by this brace.

The authors are indebted to Dr. Paul Norton and Dr. Louis Nathan for many helpful suggestions in the development of the brace.

FIG. 10

Case 2. Roentgenogram taken with the patient in the standing position and with the brace on. The lower curve is corrected slightly; the dorsal curve is corrected markedly. Note the increased width of the intercostal spaces on the left side.

REFERENCES

ABBOTT, E. G.: Simple, Rapid and Complete Reduction of Deformity in Fixed Lateral Curvature of the Spine. New York Med. J., XCIII, 1217, 1911.

Correction of Lateral Curvature of the Spine; A Simple and Rapid Method for Obtaining Complete Correction. New York Med. J., XCV, 833, 1912.

BREWSTER, A. H.: Lateral Structural Curvature of the Spine. Treatment by Means of the Turnbuckle Jacket and Turnbuckle Shell. Arch. Surg., XVIII, 1427, 1929.

CHAMBERS, F. S.: A Corrective Appliance for Scoliosis. J. Bone and Joint Surg., XVIII, 219, Jan. 1935.

SCHANZ, A.: Handbuch der orthopädischen Technik für Aertze und Bandagisten. Jena, G. Fischer, 1908.

A SIMPLE METHOD FOR THE AMBULATORY CORRECTION OF FLEXION CONTRACTURE OF THE KNEE

The Use of Continuous Elastic Tension as the Corrective Force *

BY SIDNEY S. GAYNOR, M.D. NEW YORK, N. Y.

Assistant Adjunct Orthopaedic Surgeon, Lenox Hill Hospital and the Hospital for Joint Diseases

The author begs indulgence for the addition of still another specimen to the array of apparatus designed for the correction of flexion deformity of the knee, secondary to soft-tissue contracture. The principle of continuous elastic tension is utilized as the corrective force. This continuously active tensile force appears to be more truly the reverse of the mechanism of contracture of the muscular and capsular structures causing the deformity than does the jerky stretch-and-hold principle employed by turnbuckle or ratchet. Especially gratifying is the absence of persistent discomfort, requiring the habitual use of analgesic or soporific drugs, which so constantly accompanies correction by the more rigid mechanisms.

Fig. 1

Fig. 2

Fig. 1: Lateral roentgenogram of the knee and apparatus showing the amount of extension obtained before weight-bearing is allowed.

Fig. 2: Lateral roentgenogram taken following Figure 1. The patient is actively flexing the knee against the corrective tension, thus indicating the range of motion allowed by the apparatus. The elastic bands are not radio-opaque and, therefore, are not visualized.

* From the Lenox Hill Hospital, Department of Orthopaedic Surgery, Service of Charles H. Jaeger, M.D.

The amount of elastic tension needed for rapid extension does not prevent the patient from actively flexing the knee through the range of previous correction (Figs. 1 and 2). The fear of limitation of motion in extension, due to the organization of intra-articular effusions in the subacute and actively chronic arthritides, is thus banished. The healthy impetus imparted to muscular and capsular physiology by active joint motion avoids the extended periods of physiotherapy required subsequent to correction by the less elastic systems.

The malleoli and the infrapatellar, suprapatellar, and lower gluteal regions are protected against undue pressure by felt pads, and a circular plaster-of-Paris casing is snugly molded over stockinet from the toes to the groin. The casing is divided by the removal of a wedge of plaster, tapering posteriorly, from over the knee. The thigh and leg plaster cuffs thus formed are then articulated by two swivel hinges incorporated into their lateral aspects. Two pairs of small cup hooks are screwed into the anterior aspects of each cuff, and long, thin rubber bands are then suspended from them so as to cross the joint. (See Figures 3 and 4.) The patient is returned to bed, and the leg cuff is suspended in a canvas sling

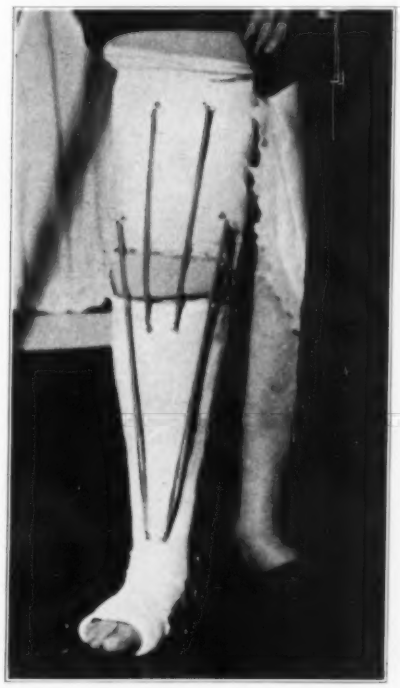


FIG. 3

FIG. 4

Fig. 3: Patient ambulatory. Front view. The arrangement of the cup hooks and elastic bands is clearly depicted.

Fig. 4: Patient ambulatory. Side view. Note the edges of the three protective felt pads and the position of the incorporated hinge. The heel and malleoli are generously exposed to avoid friction and pressure at those points.

so weighted as to counterbalance its inertia and thus allow the elastic tension to operate solely upon the contracture. One or two bands are added daily to each series of hooks.

After a short period of recumbent correction, enough extension is obtained to enable the patient to walk in his apparatus with the aid of crutches. This is managed quite easily, for the knee enjoys an excursion of from 15 to 20 degrees with each step. Hospitalization is thus terminated at a relatively early date, and the progress of the case is followed from the Out-Patient Department. Another decided advantage of this method over those previously employed is that it avoids the use of any retentive postcorrective brace or cast, for the primary corrective apparatus may be used in such capacity for as long a time as the surgeon deems necessary.

No originality is claimed by the author for the employment of continuous elastic tension in the treatment of flexion contracture of the knee. It is desired merely to present a simple apparatus, embracing this principle, which has proved successful in his hands.

The writer wishes to thank Dr. Charles H. Jaeger for the opportunity of developing this method in the treatment of cases upon his Service, Dr. Walter I. Galland for his suggestions and encouragement, and Dr. Raymond Gettinger for his kindness in taking the photographs used as illustrations.

BENIGN ;T-CELL TUMOR OF THE FOURTH LUMBAR VERTEBRA

A Case Report

BY GEORGE A. DUNCAN, M.D., NEW YORK, N. Y.
Fellow of New York Orthopaedic Dispensary and Hospital

AND ALBERT B. FERGUSON, M.D., NEW YORK, N. Y.
Director of Roentgenology, New York Orthopaedic Dispensary and Hospital

The occurrence of giant-cell tumor involving the vertebral arch and body is so unusual and the methods of treatment have been so varied that it seems worth while to add the following case to the fifty which have been reported in the literature. The treatments employed have included atoxyl, Coley's serum, roentgen ray, radium, and partial or complete surgical removal. In one case bone chips were placed in the cavity. Our patient was treated as in the last instance, but spine fusion was also done to prevent the vertebral collapse and cord-pressure symptoms which have frequently resulted in the reported cases. The result obtained was cure of the tumor and complete relief of symptoms.

CASE REPORT

An Italian girl, aged seven, was admitted to the New York Orthopaedic Dispensary and Hospital on October 21, 1927. She had had pain in the region of the left hip for four months. There was no known injury or illness associated with the onset. The pain had increased in severity, but no limp had been noticed by the child or by her parents. She attended school regularly and ran about quite freely. Occasionally she was forced to sit down and rest because of slight pain in her back. She slept well without night cries and was most comfortable lying on her back. Her appetite was poor. She had no cough, hemoptysis, or night sweats. Her father had active pulmonary tuberculosis at this time.

Physical Examination

The child was well developed and nourished. The examination was essentially negative except as follows:

Abdomen: The left lower quadrant was quite tender on palpation and felt fuller than the right side.

Spine: A small kyphos was present at the first lumbar vertebra. Tenderness was present at the spine of this vertebra, but was greater over the lower lumbar spines. The entire lumbar spine was held rigidly and all motions were limited 50 per cent. by pain or spasm.

Left Lower Extremity: There was atrophy of the thigh amounting to one-half an inch. No paralysis was found. The anterior and lateral aspects of the hip were slightly tender, but all motions of the hip were free except straight-leg raising, which caused considerable pain in the region of the lumbar spine.

The Mantoux test was positive, but other routine laboratory examinations were essentially negative.

Roentgenographic Examination

A roentgenogram taken on October 21, 1927 (Fig. 1) showed the entire left transverse process of the fourth lumbar vertebra to be expanded to more than three times its normal diameter. Cortex was present over the whole mass, but was thinned almost to the point of invisibility. No trabeculae were visible within the tumor, although a few dense lines were present which apparently represented ridges in the cortex. The lesion extended into the pedicle and thence slightly into the body of the vertebra. The left psoas muscle was prominent opposite the mass. The intervertebral discs were not affected. The bone shadows were clear and there was no obscuring of detail as would be apparent if the lesion were purulent. At this time it was thought that the lesion might be an enchondroma.

On February 1, 1928 the lesion had increased in size and had extended into the lamina and body (Fig. 2). Most of the left half of the vertebral body was then involved. The third lumbar vertebra was slightly displaced to the left on the fourth vertebra and was tilted in the same direction. It was thought that the rapid increase in size of the lesion was due to hemorrhage within it, but this was not substantiated at operation.

Treatment

The patient entered the hospital on March 6, 1928. Her symptoms had abated considerably, but the rapid progress of the tumor seemed to indicate the necessity of

FIG. 1

October 21, 1927. Before operation. Showing involvement of the entire left transverse process and a small portion of the pedicle and body of the vertebra.

FIG. 2

February 1, 1928. Before operation. Showing increase in the size and extent of the lesion.

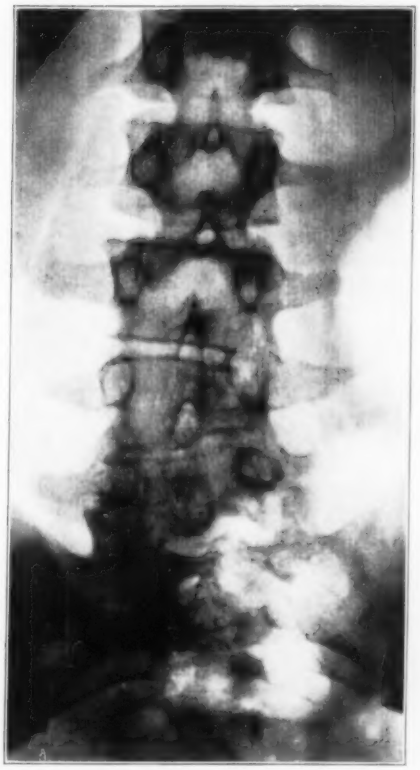


FIG. 3-A

FIG. 3-B

January 14, 1933. After operation. Anteroposterior and lateral views, showing solid spine fusion and no evidence of recurrence of the tumor.

immediate treatment. Roentgen-ray therapy seemed inadvisable in view of the proximity of the lesion to the kidneys and pelvic organs. Exploration of the tumor was undertaken on March 28, 1928 by Dr. H. L. von Lackum.

Operative Procedure

Through a longitudinal incision adjacent to the midline, the arches of the vertebrae from the second lumbar to the first sacral were exposed by subperiosteal dissection. The left side of the fourth lumbar arch was blanched and somewhat eroded. In dissecting laterally over the transverse process, the bone shell was broken and the tumor mass appeared. It bled only moderately, was enclosed in a complete bone shell as large as a walnut, and had the appearance of tuberculous material. The contents of the shell were removed and the involved portion of the vertebral body was curetted through the pedicle. Bone shavings from the posterior aspect of the ilium were packed into the cavity in the body, pedicle, and transverse process. Fusion of the third and fourth lumbar vertebrae was performed according to the technique of Hibbs.

Pathological Report

The material consisted of fairly cellular fibrous tissue, containing many giant cells and some bone trabeculae which were undergoing absorption and destruction. Several areas of leukocytic (mostly lymphocytic) infiltration were seen. An occasional mitotic figure was noted, but no osteoid tissue.

The diagnosis was giant-cell tumor.

Subsequent Course

The patient remained in bed with a metal brace adjusted to her back. On July 31, 1928, roentgenograms revealed that new bone was developing about the chips in the cavity, and fusion of the third and fourth lumbar vertebrae appeared firm. There was no evidence of further bone destruction at this time, but some portions of the cavity in the lamina were not occupied by bone shavings.

On November 26, 1928, by means of the Hibbs technique, the spine fusion was extended from the fourth lumbar vertebra to the sacrum. It was thought that this fusion would eliminate the possibility of fracture or collapse of the vertebrae. At the same time the small remaining defect in the lamina was filled with bone shavings.

The patient was allowed up on April 10, 1929, and she was discharged from the hospital two weeks later.

The patient was last seen in January 1933, at which time she was feeling perfectly well. She denied any pain, ache, or fatigue in her back. She was quite active and had no disability. She could walk several miles easily. The fusion of the spine was solid. There was no tenderness or spasm. Motion above the fusion area was free. Were it not for the incisional scars it would be difficult to tell that there had ever been anything wrong with her back.

Roentgenograms (Figs. 3-A and 3-B), taken on January 14, 1933, revealed a solid spine fusion from the third lumbar vertebra to the sacrum. There was no evidence of recurrence of the tumor. The bone structure in the previously affected area appeared more normal than formerly.

INTRATARSAL DISLOCATION

Report of a Case of Anterior Midtarsal Dislocation

BY HENRY H. RITTER, M.D., F.A.C.S., NEW YORK, N. Y.
Associate Professor of Clinical Surgery

AND WALTER D. LUDLUM, JR., M.D., F.A.C.S., NEW YORK, N. Y.
Associate in Surgery

From the Department of Traumatic Surgery, New York Post-Graduate Medical School and Hospital, Columbia University, Reconstruction Hospital Unit

The case here reported is one which we term anterior midtarsal dislocation in contradistinction to the classical midtarsal dislocation. It is a dislocation in which the scaphoid remained in its normal relation to the astragalus and os calcis, while the remaining tarsals and metatarsals were dislocated as a unit. A search of the records of the hospitals with which we are associated revealed no other such dislocation. A review of the literature also failed to show a similar case. We could find no text-book or dictionary in which this type of injury was described. It is felt, therefore, that the case is sufficiently rare to warrant its inclusion in the literature.

A. T., a negro stevedore, aged forty-five, was injured on December 15, 1930, when a heavy, horse-drawn truck backed onto his right foot. He was crouched down in such a position that the force of the wheel was applied to the medial and plantar surface of his foot. He was unable to walk and was carried to his home.

Four hours later he was admitted to the Reconstruction Hospital. Local examination showed marked swelling of the right foot with an extremely tight figure-of-8 bandage about it and the ankle. Over each malleolus there was a swelling about the size of an orange. When the bandage was removed marked bony deformity of the foot was noted. The forefoot was displaced laterally and slightly backward. On the medial border, a distinct bony outline could be felt, which appeared to be the scaphoid in its normal contact with the astragalus. The cuboid could be felt in an abnormal position on the lateral border of the foot. The impression was that the scaphoid and metatarsals were in their normal relative positions. Roentgenographic examination (Fig. 1) showed a complete lateral and backward displacement of the distal row of tarsals.

One hour after admission, under spinal anaesthesia, closed manual reduction was attempted with some improvement. The swelling of the part was now marked. The patient was put to bed with the leg elevated in an attempt to bring down the swelling. On the following

Fig. 1

Roentgenogram showing anterior midtarsal dislocation. Fracture of the cuneiform is also evident.

day, again under spinal anaesthesia, further manual manipulation was attempted with no improvement. The Moorhead repositor with 100 pounds of traction on the forefoot also failed to accomplish the desired result. On December 17, 1930, again under spinal anaesthesia, repositor reduction was once more attempted without success. Two attempts at manual and two attempts at repositor reduction had been unsuccessful.

After four days, during which the leg was elevated and wet dressings were applied, the swelling and inflammatory reaction had subsided to a marked degree. A Steinmann pin was inserted through the metatarsals and another through the os calcis. The knee was then flexed to an angle of 135 degrees and the patient was put to bed. Six and one-half pounds of traction was applied to the posterior pin and eleven and one-half pounds to the anterior pin (Fig. 2).

Twenty-four hours later, examination showed a rather marked improvement in the condition of the foot. The swelling had receded and the anatomical alignment seemed perfect. Roentgenograms were made with the nails in place (Fig. 3) and showed an almost complete reduction.

On January 16, 1931 the swelling had entirely receded and a plaster-of-Paris casing was applied, incorporating the nails. Roentgenograms verified the excellent reposition of the parts. On January 19, 1931 the nails were removed without anaesthesia. The plaster-of-Paris casing was not disturbed and roentgenograms taken immediately showed the position to be maintained. It is worthy of note that a fracture had occurred through the head of the fourth metatarsal at the point of transfixion.

FIG. 2

Showing Steinmann pins in place and traction and countertraction applied.

On February 19, 1931 the plaster casing was removed and the part was inspected. It was deemed advisable to continue immobilization with the ankle placed in dorsiflexion at an angle of 80 degrees. The foot was kept in midposition throughout treatment and was neither everted nor inverted. A plaster casing with walking iron was applied.

On March 25, 1931 this casing was removed. Motion of the ankle was from 110 to 130 degrees. Moderate inversion and eversion of the foot were possible. Flexion of the toes was present, but extension was lost. Roentgenographic examination showed that the reduction was maintained. The fracture through the head of the fourth metatarsal was firmly united and the fragments were in good position. Periarticular disuse atrophy was noted in the bones of the ankle and foot.

On March 29, 1931 the patient complained of pain in his foot and a plaster-of-Paris casing with walking iron was again applied. The casing was removed on April 16, 1931. Active motion of the ankle was noted from 90 to 110 degrees; extension of the toes was still lacking. A combination Whitman foot plate was ordered and applied on April 25, 1931. On June 4, 1931 motion of the ankle was found equal to that of its mate. Alignment of the bones was good. The fracture of the fourth metatarsal was firmly united. On July 25, 1931 all motion was normal, with the exception of the great toe.

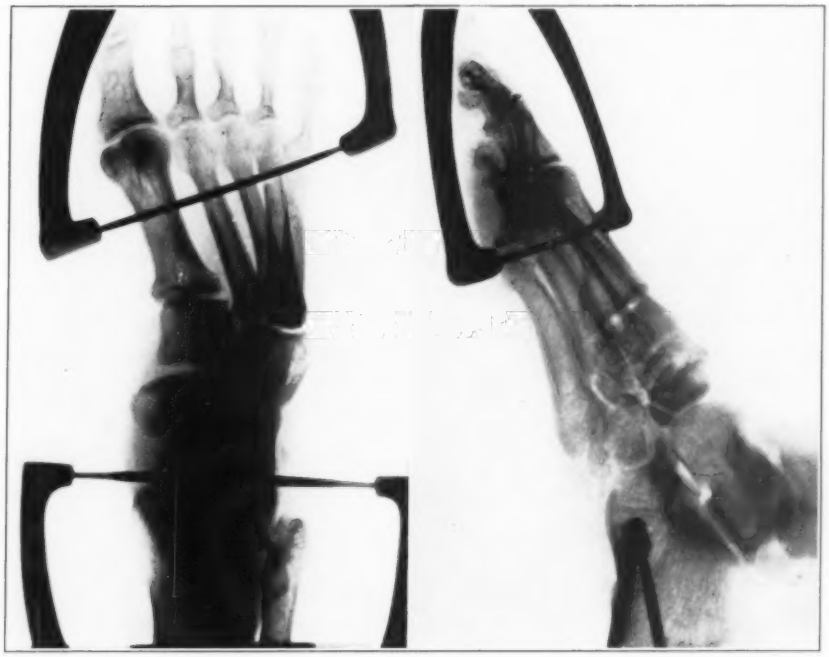


FIG. 3

Roentgenograms of foot showing the pins in place and the reduction obtained.

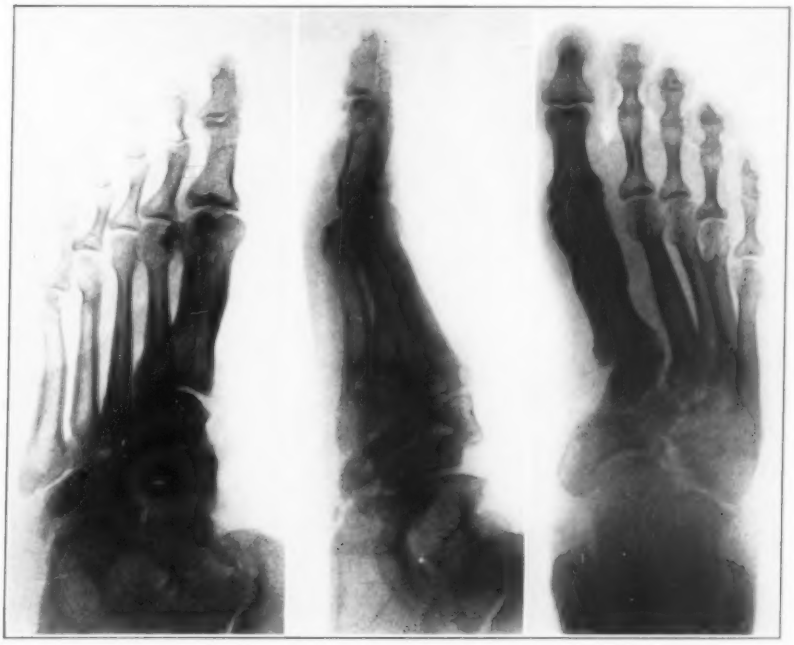


FIG. 4

Roentgenograms taken at the time of discharge.

Follow-up examination on September 20, 1932 showed that the patient walked without a limp. He could walk on his heels or on his toes. He hopped about the room on the affected foot without difficulty. He was able to climb stairs and to climb the rungs of a ladder. He had no brace and no plate in his shoe. The foot appeared normal except for bony thickening over the scaphoid. On November 5, 1932 he was discharged as cured.

SUMMARY

This patient exhibited a complete anterior midtarsal dislocation without abrasion or laceration of the skin. The distal tarsus was dislocated laterally. Manipulative reduction was attempted four times without success. Reduction by skeletal traction and countertraction was successful and the end result is a practically complete functional restoration of the foot.

BILATERAL RECURRENT DISLOCATION OF THE ULNA AT THE ELBOW

BY HENRY MILCH, M.D., F.A.C.S., NEW YORK, N. Y.

Associate Attending Orthopaedic Surgeon at the Hospital for Joint Diseases *

As far as can be discovered, the following case is unique in the world's literature. No one with whom the author has spoken has ever seen or heard of a similar case. It is interesting to note that one other case of recurring luxation of the ulna at the elbow has been recently described by Sorrel [1]. It appears, however, that Sorrel's case was unilateral and apparently traumatic in origin. The case herewith reported is bilateral and congenital in nature.

W. S., male (Hospital No. 56720, Out-Patient Department No. B 19534), was first seen in the Out-Patient Department of the Hospital for Joint Diseases at the age of eight on November 29, 1926. It was stated that the first dislocation of the elbow had occurred at the age of fourteen months. He had had no trouble from that time until he was seven years old, when he fell and again dislocated the elbow. In October 1926, following another fall, he suffered a supracondylar fracture of the right humerus, which had been treated at a city hospital before the patient came to the Hospital for Joint Diseases. The convalescence was uneventful.

In February 1930, the patient again fell and the roentgenogram was reported as showing a slight posterior dislocation of the right elbow. This was reduced and the patient remained well until the following September, when another dislocation developed, following another fall. (See Figure 1.) At this time it was first noted that the semilunar notch (greater sigmoid cavity) was definitely flatter and shallower than normal. The dislocation was reduced. Since that time the patient has had repeated dislocations,—the right elbow, five times and the left elbow, four times. On December 20, 1935, at the age of seventeen,

FIG. 1

Roentgenogram, taken September 29, 1930, showing posterior dislocation of the right ulna. Note the almost straight line of the semilunar notch.

* From the Service of Harry Finkelstein, M.D.

the patient again appeared in the Clinic with the statement that he had dislocated the right elbow while tying his shoe lace the previous night. A roentgenogram (Fig. 2), which was taken immediately, showed no evidence of dislocation.

Although the dislocation had apparently been reduced spontaneously, it was observed that the shallowness of the semilunar notch previously noted still persisted. When compared with that of a relatively normal elbow of a child of the same age, it was found that the semilunar notch of the normal child, from the tip of the olecranon to the tip of the coronoid, measured approximately one and seven-sixteenths inches in length and subtended a central angle of 122 degrees in a circle with a radius of eleven-sixteenths of an inch, while the semilunar notch of this patient measured one and seven-sixteenths inches and subtended an angle of 94 degrees in a circle with a radius of fourteen-sixteenths of an inch. The difference in the degree of convexity can be readily gauged from these figures and is graphically shown in Figure 3 which represents the arcs of the two semilunar notches as traced from the roentgenograms.

It was felt that this represented a true deviation from the normal and was the possible cause of the recurrent dislocations. With this idea in view, the patient was admitted to the hospital for the purpose of performing a bone-block operation at the tip of the coronoid process, so as to prevent future dislocations. Examination disclosed no limitation of motion or abnormality of motion at the elbow. The carrying angles of both arms were obliterated. All the laboratory examinations were essentially normal.

Operation was performed on January 9, 1936 under general anaesthesia. A four-inch incision was made on the anteromedial aspect of the right elbow, directly over the course of the brachial artery. The median basilic vein was then tied and the bicipital lacertus fibrosus was incised. This permitted a view of the medial border of the biceps brachii which was retracted laterally along with the brachial artery and vein. The median nerve was next identified and retracted medially. This exposed the longitudinal fibers of the brachialis anticus at the bottom of the wound. These were split in a longitudinal direction, exposing the capsule which was opened longitudinally directly over the blunted tip of the coronoid process. A quarter-inch drill hole was then made in the ulna, beginning at the tip of the coronoid process and extending obliquely backward and downward into

FIG. 2

Roentgenograms of both elbows at time of admission to the hospital in December 1935. Note that the line of the semilunar notch is still only very shallow.

the body of the ulna. The wound was then temporarily closed while a boomerang-shaped bone graft about one and one-half inches long was removed from the anterior ridge of the tibia. This was carefully placed into the coronoid hole previously prepared, so that the beak of the graft pointed upward as if continuing the curve of the semilunar notch. This extended and enlarged the notch. With this fragment *in situ*, it was possible to completely flex the elbow, the graft apparently entering the coronoid fossa. The capsule was then closed behind the graft, the longitudinal fibers of the brachialis anticus were

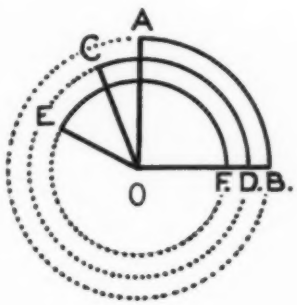


FIG. 3

Concentric circles showing graphically the radius of curvature, the actual length of the arc, and the angle subtended on the x-ray by the normal and abnormal and reconstructed semilunar notches.

$AB = CD = \frac{23}{16}$ in.
$OC = \frac{11}{16}$ in.
$OA = \frac{14}{16}$ in.
Angle $AOB = 94°$
Angle $COD = 122°$
Angle $EOF = 159°$
$OE = \frac{19}{32}$ in.
$EF = \frac{25}{16}$ in.

FIG. 4-A

X-ray showing the bone graft *in situ*. Note increase in the convexity, as well as in the length of the semilunar notch, as compared with the preoperative x-ray. (See Figure 2.)

FIG. 4-B FIG. 4-C

Showing extent of flexion and extension in March 1936.

sutured in front of the graft, and the skin was closed with silk. A plaster-of-Paris bandage was applied with the elbow in flexion for a period of two weeks, after which all dressings were removed. After the bandage was removed, the arm was allowed to hang down, so that gravity tended to restore complete extension. By the middle of March, all motions had returned to normal except for slight limitation of extension (Figs. 4-B and 4-C). The roentgenogram (Fig. 4-A) showed "a well formed bone peg, well placed in the coronoid process and enlarging the extent of the sigmoid cavity". By actual measurement of the x-ray tracing it was found that the new semilunar notch measured one and nine-sixteenths inches and subtended an arc of 159 degrees in a circle with a radius of nineteen thirty-seconds of an inch. When the patient was last seen at the end of five months, there was still no evidence of any recurrence. The case is reported more for the unusual nature of the condition than for the certainty of the satisfactory operative result. The left elbow will be operated upon as soon as symptoms of dislocation appear.

The mechanical problem presented by this case lent itself to a number of theoretical solutions. First, it would have been possible to reef or to reenforce the collateral ligaments; but the experience gained in capsuloplasties in other dislocations was such as not to make this prospect too alluring. Secondly, the possibility of modifying the convexity of the sigmoid notch by performing a juxta-articular osteotomy was considered. This, too, was discarded when it was realized that success might involve a serious disturbance in the radial notch and, therefore, in the motion of pronation and supination of the forearm. There remained, finally, the possibility of bone block. Sorrel was apparently successful in preventing dislocation by raising an oblique buttress parallel to the lower and outer rim of the olecranon fossa. The principle which guided Sorrel was the prevention of the outward gliding which was secondary to a presumed relaxation of the ulnar collateral ligament. In our case there appeared to be a definite congenital malformation of the semilunar notch and the indication was definitely to correct this. Two methods of accomplishing this were considered,—one, a bone graft into the coronoid fossa, and the other, osteotomy and forward flexion of the tip of the olecranon process, so as to prevent complete extension. The former of the two methods was chosen. Whether or not the result will be permanent only time can tell.

REFERENCE

1. SORREL, E.: Luxation récidivante du coude. Opération. Guérison. Bull. et Mém. Soc. Nat. de Chir., LXI, 790, 1935.

EXTENSION DEFORMITIES OF THE PROXIMAL INTERPHALANGEAL JOINTS OF THE FINGERS.

An Anatomical Study

BY EMANUEL B. KAPLAN, M.D., NEW YORK, N. Y.

Adjunct Orthopaedic Surgeon, Hospital for Joint Diseases *

The object of this paper is to show the results of a few experimental observations made on cadavera with the purpose of explaining the mechanism of the often observed hyperextension deformities of the proximal interphalangeal joints of the fingers.

As is well known, an investigation of this sort, connected with muscle activities, cannot be considered complete unless at least three known methods of study are used. The anatomical method, the first employed historically, should perhaps be followed by the electrical method, introduced by Duchenne, and by the physiological method. This last, based on the study of normal muscular contractions in normal living subjects and in spastic and paralytic patients, completes the description of muscle action and corresponding motion of the joints. Thus, the limitations that such a study involves are well recognized.

The following two cases stimulated the present investigation:

Case 1. H. W., a male, fifty-six years old, who presented a bilateral Dupuytren's contraction involving the fourth finger only, accidently struck the distal phalanx of the fourth finger of the right hand against an obstacle. After the accident the patient noticed that the tip of this finger remained flexed. The patient, who is a chauffeur, did not have much trouble with the Dupuytren's deformity. However, the finger-tip drop was definitely troublesome, and this prompted him to seek medical advice.

At operation, through an inverted L incision, the palmar fascia was removed. The torn extensor tendon at the distal interphalangeal joint was sutured through a dorsal incision over the fourth finger. After the operation a palmar splint was applied, which held all three phalanges of the fourth finger in extension. Subsequently a very small slough developed at the corner of the incision, but this healed rapidly.

Several weeks later it was noticed that the flexion of the distal phalanx of the fourth finger had recurred. At this time it was found that there were no adhesions between the skin and the tendon sheath of the fourth finger; thus, Dupuytren's contraction was apparently eliminated. The proximal interphalangeal joint of the fourth finger was kept hyperextended and the distal phalanx slightly flexed. The metacarpophalangeal joint was maintained in very slight flexion. The interossei of the fourth finger were functioning perfectly. Apparently the lumbricales were also functioning very well. Lateral motion of the fourth finger was excellent and active flexion at the metacarpophalangeal joint was normal. The fourth finger, when flexed at the metacarpophalangeal joint, was kept hyperextended at the proximal interphalangeal joint until the angle of flexion at the metacarpo-interphalangeal joint reached 90 degrees; then the proximal interphalangeal joint started to flex and only then did it flex normally with the other fingers, although further down it lagged again and could not be flexed completely to make a fist. When the flexed fingers were extended from the position of a fist, it could be noticed that the two distal phalanges of the fourth finger were extending very much faster than the prox-

*Service of Harry Finkelstein, M. D.

imal phalanx of this finger. The proximal phalanges of the other fingers were already extending while the proximal phalanx of the fourth finger was still resting. At further extension, the two distal phalanges were more extended than the proximal phalanx, and a marked hyperextension at the proximal interphalangeal joint was then noticed. This angle was maintained up to the limit of extension of the finger at the metacarpophalangeal joint.

CASE 2. N. X., a male, eighteen years old, had sustained an injury to the right middle finger while playing baseball. The ball had hit the volar surface of the distal part of this finger and acute pain had followed. The patient was treated for the pain and for a gradual disability which developed subsequently and which consisted in an inability to flex the finger at the proximal interphalangeal joint after full extension of the three phalanges.

The patient came for examination nine months after the original injury. He had a marked hypotonia of most of the joints, especially noticeable in the smaller joints of the hand. The injured finger could be passively hyperextended to about 205 degrees at the proximal interphalangeal joint. This finger could be actively hyperextended to about 190 degrees at the same joint. After full voluntary hyperextension of the finger, an attempt to flex all of the fingers (to make a fist) resulted in normal flexion in all of the fingers except the middle one, which remained hyperextended at the proximal interphalangeal joint. The distal phalanx of this finger was the only one that flexed almost to 100 degrees. Two distinct lateral cords of the collateral extensor tendon of the finger could be seen to be very tense under the skin of the dorsal aspect of the finger. No matter how hard the patient tried to flex this finger it would remain hyperextended at the proximal interphalangeal joint. This injury interfered very much with the activities of the boy. Lateral motion of this finger and of the other fingers was normal.

There was evident a certain similarity in these two cases. In order to find an explanation of the mechanism of this interphalangeal deformity, this study has been undertaken. The problem was to identify the structure, the injury of which was responsible for the deformity, and to reproduce if possible the condition which has been described. The results were as follows:

A cadaver of a female, twenty-four years old, was first examined. The hands did not show any abnormalities. The fingers could be flexed and extended normally. The third, fourth, and fifth fingers of the right hand were chosen for the investigation. Two small incisions were made on the lateral and medial sides of the fifth finger; the proximal interphalangeal joint was approached; and the tendon sheath, together with the tendons, was completely separated from the anterior capsule of this joint. With a pointed knife, the anterior ligament of the capsule was cut, and an attempt to hyperextend the proximal interphalangeal joint produced a very slight hyperextension. The tendon of the flexor sublimis was then cut, and the hyperextension was slightly increased. The same procedure was repeated on the fourth finger, but both tendons, the flexor sublimis and the flexor profundus, were cut across. Even then, however, there was only very slight hyperextension. On the third finger, the collateral ligaments of the finger, in addition to the anterior ligament, were cut, leaving the flexors intact. In this case a marked hyperextension followed at the interphalangeal joint.

The second observation was made on a male cadaver, thirty-five years old, with normal hands. Two lateral skin incisions were made through which the capsule and collateral ligament of the proximal interphalangeal

joints were approached and cut across. The tendons were left intact and a slight hyperextension could then be produced manually. The extensor digitorum communis tendon was exposed on the dorsum of the finger. A pull on this tendon produced extension of the first phalanx only. The tendons of the lumbricales and interossei were then exposed. A pull on the lumbricales produced hyperextension of the proximal interphalangeal joint without radial deviation. Although the pull was produced on one lumbricalis only, two distinct cords, equally tense and corresponding to the expansion of the extensor digitorum communis tendon, could be observed under the skin of the dorsum of the finger. From the interphalangeal joint up to the distal phalanx, the pull on the tendons of the interossei produced almost equal tension of the above mentioned cords with similar hyperextension. The tendon of the flexor sublimis was cut across the line of the interphalangeal joint of the same finger. This was followed by considerable hyperextension, which could be obtained by bending the finger at this level. The same amount of hyperextension was obtained by pulling the lumbricalis tendon. There was no radial deviation of the finger and again the two tendon cords could be seen on the dorsum of the finger. The pull on the interossei tendons produced almost equal hyperextension at the proximal interphalangeal joints and normal extension of the distal phalanx. Next, the capsule was left intact and the tendon of the flexor sublimis only was cut across the joint. The result of this experiment, made through two lateral skin incisions, was very much less pronounced than in the previous experiment when the capsule also was cut.

With the lumbricales, interossei, extensor digitorum communis, and flexor digitorum tendons exposed, a deformity similar to the one observed on the patients could be easily reproduced in the following fashion: The anterior capsule, the collateral ligaments of the interphalangeal joint, and the bifurcation of the sublimis tendon were found lying across the joint line; the pull on the lumbricales fixed the proximal phalanx in extension, and, at the same time, the pull on the flexor digitorum profundus produced a hyperextension at the proximal interphalangeal joint and a flexion of the distal phalanx of the finger.

Repair of the anterior capsule, including the collateral ligaments, which produced a very slight flexion of the proximal interphalangeal joint, was sufficient to prevent the deformity, in spite of the fact that the cut sublimis tendon was left unrepaired.

Thus, it appears that a reconstruction of the anterior capsule and of the collateral ligaments of the proximal interphalangeal joint, which produces a slight flexion to restrict the angle of action of the lumbricales and interossei, could produce a satisfactory elimination of the hyperextensive activity of these muscles at the proximal interphalangeal joint. This procedure would not eliminate the normal abductor, adductor, and partial-extension activity of the interossei and lumbricales; neither would it eliminate the flexor action of these muscles on the first phalanx. Better functional results could perhaps be expected subsequently.

A THREE-POINT HYPEREXTENSION BACK BRACE

BY R. A. GRISWOLD, M.D., LOUISVILLE, KENTUCKY

From the Department of Surgery of the Louisville City Hospital and the University of Louisville School of Medicine

Considerable experience in the ambulatory treatment of compression fracture of the spine by the method of Watson Jones[1] has recently led the author to the conclusion that an efficient adjustable hyperextension back brace might be of value in such cases. Such a brace should supply and hold any desired degree of hyperextension, should avoid the discomfort and hygienic disadvantages of a plaster jacket when worn for three or more months, and should not deteriorate during the period of use.

The purpose of hyperextension is to bend the deformed spine, so that the abnormal angulation at the point of kyphosis is corrected. The most efficient mechanical means of bending a rod or column is to place a fulcrum at the point of desired angulation and to apply counterpressure at both ends of the column. No other points of contact are necessary. In the conventional type of back brace, a fulcrum is formed by full-length rigid posterior bars. Counterpressure is applied around the pelvis by straps attached to the lower ends of the bars and around the chest and shoulders by straps from the upper ends of the bars. The straps around the chest are relatively ineffective because of the wide range of respiratory movement. Pressure applied to the soft parts of the shoulders must be transmitted through the clavicles to the sternum, thence to the upper ribs, and finally to the spine. The instability of the mobile shoulder girdle greatly reduces the efficiency of this complicated transfer of force, so that only partial immobilization of the spine is obtained.

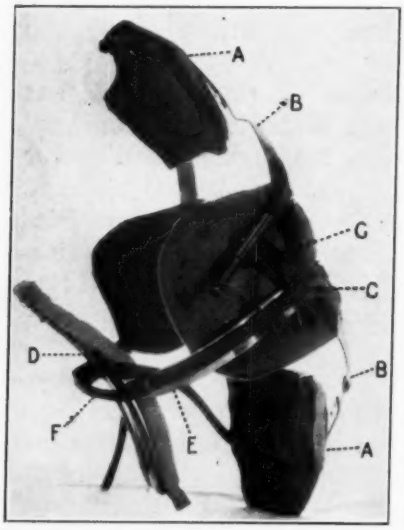


FIG. 1

Showing the details of the brace: the anterior pressure pads (*A*); the hyperextension bars (*B*) which pivot at the swivel joints (*C*); the posterior fulcrum (*D*) which is adjusted by the removable yoke (*E*) and straps (*F*); and the hyperextension screw (*G*) which forces the plates (*A*) backward.

The brace illustrated was developed in an attempt to apply mechanically effective counterpressure to the spine at both ends of the trunk against a posterior fulcrum at the peak of the kyphos. Backward pressure is applied to the lower end of the spine from the symphysis pubis directly through the pelvis to the sacrum. At the upper end, pressure

is transferred by the most direct bony route, through the manubrium and short upper ribs to the superior thoracic spine. Hyperextension is positive and may be increased slowly or rapidly to any desired degree. Only the three essential points of contact are utilized. Long posterior bars and encircling straps are not necessary. This results in the minimum of interference with thoracic and abdominal movement and makes most of the trunk accessible. The small forward excursion of the first two or three ribs causes little reduction in efficiency.

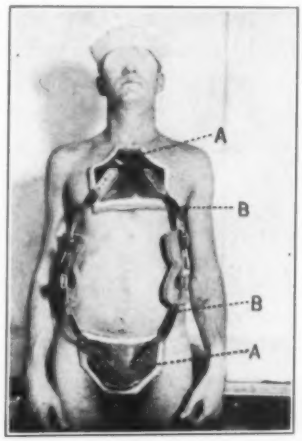


FIG. 2

Anterior view, showing anterior plates (*A*, *A*) and bars (*B*, *B*).

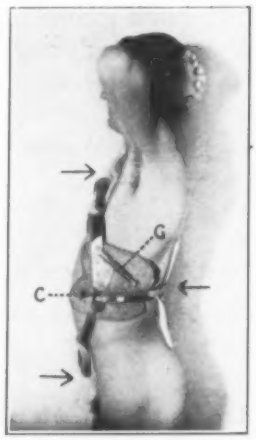


FIG. 3

Lateral view, showing force exerted at the three essential points.

Over the symphysis pubis and upper sternum are padded, form-fitting stainless-steel plates (Figs. 1, *A* and 2, *A*). Hinged to each of these plates are steel bars (Figs. 1, *B* and 2, *B*) which curve to swivel joints (Figs. 1, *C* and 3, *C*) at the sides of the trunk. These bars are adjustable in length, so that the joint may be raised or lowered to a point opposite the kyphos and in order that the brace may be adjustable enough to fit patients within a reasonable range of size. The posterior fulcrum (Figs. 1, *D* and 4, *D*) is a curved rectangular steel or aluminum-alloy plate, the center of which is cut out over the spinous processes. The fulcrum is attached to and adjustable upon a steel or aluminum-alloy yoke (Figs. 1, *E* and 4, *E*), the ends of which run through slots at the joints. By means of this yoke and the straps (Fig. 1, *F*) the fulcrum may be moved forward or backward in relation to the joint and the anterior plates. With the fulcrum fixed in relation to the joints, the anterior plates may be moved backward by the screw (Figs. 1, *G* and 3, *G*), which changes the angle between the side bars to an alignment more nearly parallel to the longitudinal line of the body.

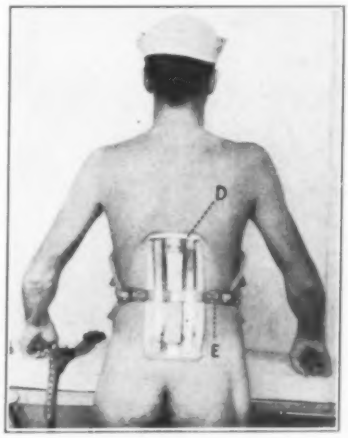


FIG. 4

Posterior view. The fulcrum plate (*D*) is open in the center to prevent pressure on the spinous processes. It is movable up and down on the yoke (*E*).

The brace is applied with the screw released. The fulcrum is first adjusted as snugly as possible by means of the yoke and straps. The screws are then tightened until the proper position is obtained. The firm, powerful, yet comfortable hyperextension which may be obtained with this brace can best be appreciated by comparing it with that secured with the conventional type of brace. While this appliance was designed for the convalescent support of compression fractures of the lumbar and lower dorsal spine, it is hoped that it will prove useful in other conditions in which positive controlled hyperextension is desired.

The author is indebted to Mr. A. C. Wilde to whom is due a great deal of credit for working out the mechanical details of the brace and for numerous improvements on the original idea.

1. Jones, R. Watson: The Treatment of Fractures and Fracture Dislocations of the Spine. J. Bone and Joint Surg., XVI, 30, Jan. 1934.

A METHOD OF IMMOBILIZING THE CHEST

BY ADOLPH M. BROWN, M.D., CHICAGO, ILLINOIS

Recent innovations in methods used to immobilize the chest indicate the effort to provide greater comfort, and the growing conviction that not two-thirds, but the entire chest must be strapped to obtain adequate immobilization. The method here offered was first used for a fractured sternum. The procedure proved surprisingly comfortable and effective and it is now used to immobilize the chest for rib fractures and pleurisy.

First, the entire thorax is powdered thoroughly with talcum. The patient slips into a knitted, snugly fitting, buttonless undershirt. Body-size stockinet may be used, but an ordinary undershirt is more simple and effective. The undershirt selected should be of the type which is knitted in tubular fashion to avoid longitudinal seams, and should not have very large armholes. The adhesive strips are three inches in width and long enough to encircle the thorax completely and to overlap several inches. The adhesive is strapped horizontally during complete expiration. The lowest strip is applied first, and each strap overlaps the preceding one by about one and one-half inches. The edges need not be parallel; one should seek rather to get close approximation to the individual thoracic contour.

FIG. 1

This simple method is extremely satisfactory and its advantages are apparent, since it does not require reapplication, and shaving is unnecessary. The strapping does not slip (as it does when applied directly to the skin); the shoulder straps of the undershirt and the close application of the adhesive tape to the natural chest slope keep it firmly fixed. There is no annoying pull on the skin and zinc-oxide excoriation is eliminated. This method of splinting effectively restricts excursion of the thoracic cage without the unpleasant sensation of stickiness.

Infra-red radiation and direct-heat therapy, which are of recognized benefit for pleurisy, do not interfere with the effectiveness of this method.

A SIMPLE ADHESIVE BOOT FOR THE PREVENTION OF FOOT-DROP IN TRACTION-SUSPENSION PROCEDURES

BY H. DAVIS CHIPPS, M.D., PICKWICK DAM, TENNESSEE

From the Orthopaedic Clinic, Employees Hospital, Fairfield, Alabama*

There have been numerous devices for the prevention of foot-drop in traction and suspension procedures, ranging from leather and web sandals to rather complicated metal affairs. For one reason or another, they have largely been discarded, and resort has been made to a simple adhesive strap on the sole of the foot tied to an overhead traction. The difficulty with this, the simplest possible method, is that the sole of the foot makes a poor surface for the adhesive to stick to, and the adhesive frequently comes off and must be renewed. To overcome this and the other objections, the author has devised an adhesive boot (Figs. 1 and 2) which has proved effective.

FIG. 1

A large piece of adhesive, twelve inches by twenty-six inches, is used. This is preferably the water-proof type which has a crinoline protection over the adhesive surface, although plain adhesive without the crinoline is quite satisfactory. With the crinoline still adherent, the adhesive is cut with scissors, as shown in Figure 2. The crinoline is then removed except from the strip leading from the toe, to which the traction rope is tied. The holes shown are cut with scissors after the edges have been folded back. The boot is applied to the foot and laced with short lengths of roller bandage (Fig. 1). This gives a close-fitting adhesive boot that is stuck not only to the sole but to all surfaces of the foot and the ankle.

* Service of H. Earle Conwell, M.D.

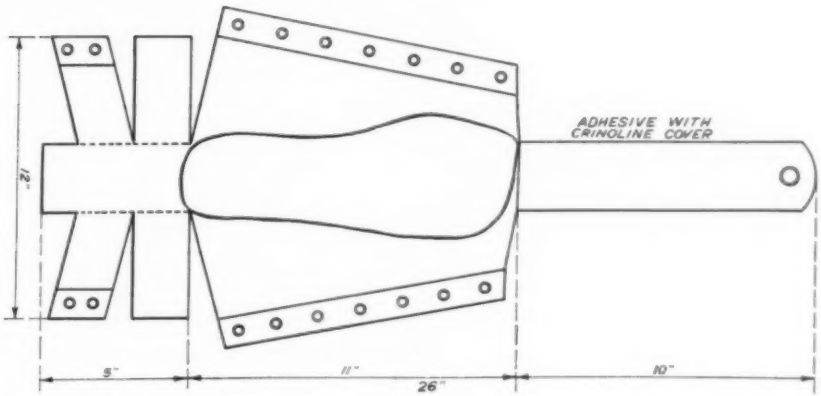


FIG. 2

This apparatus is simple, easily available, and of negligible cost. It can be fitted under a close-fitting traction apparatus, and it does not interfere with active and passive motion of the ankle. Most important, the boot will not come off accidentally.

THE ISCHIAL SEAT BRACE

A Substitute for the Thomas Ring Brace

BY WALTER I. GALLAND, M.D., NEW YORK, N. Y.

*From the Lenox Hill Hospital and the Hospital for Joint Diseases**

The medical profession will always be indebted to Hugh Owen Thomas for the principle of unweighting a pathological lower extremity by transferring the body weight to the ground through the intermediation of a brace with an ischial weight-bearing component. The Thomas ring-brace, which was initially devised for relieving the tuberculous knee of weight-bearing stresses, has long been adopted in various modifications for a wide variety of conditions requiring weight-free function of the lower extremity.

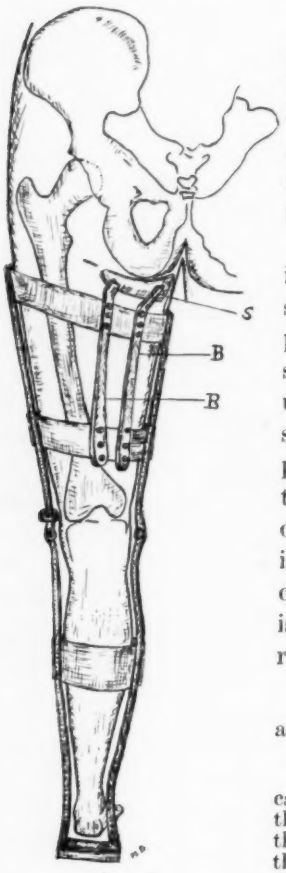


FIG. 1

It is a common experience that few brace-makers are able to construct a Thomas ring which is reasonably comfortable and, at the same time, effective. The substitute which is herewith presented aims to provide a support which is readily adjustable to the ischium and which causes a minimum of discomfort to the patient.

The essential feature of this ischial support is a comma-shaped seat made of metal. It is so shaped that it is slightly concave on its superior or ischial surface. The dimensions of the seat vary with the size of the patient; the measurements of a seat made for an adult of average size are given in Figure 3. The comma-shaped plate, which forms the seat, is articulated with the posterior thigh bands of the brace by means of two extension bars (Fig. 1, *B*, *B*). The plate is mounted on these bars so that the head of the comma-shaped saddle lies directly under the ischium. The concave upper surface of the seat receives and supports the convex surface of the

* Orthopaedic Services of Charles H. Jaeger, M.D., and Harry Finkelstein, M.D.

Fig. 1: Diagrammatic sketch of ischial seat brace, indicating the manner in which the ischium is supported by the seat *S*, which is articulated with the brace by means of the extension bars *B*, *B*. The seat as sketched is fixed to the extension bars and does not change its position when the patient sits down.

tuber ischii. The tail of the comma-shaped seat is directed laterally along the line of the gluteal fold. The extension bars which join the saddle to the brace are provided with a series of closely placed screw holes, so that accurate adjustment of the seat is possible, both as to height and to inclination. The seat should be amply padded to secure maximum comfort. The author has found a padding of lamb's wool or factis most satisfactory.

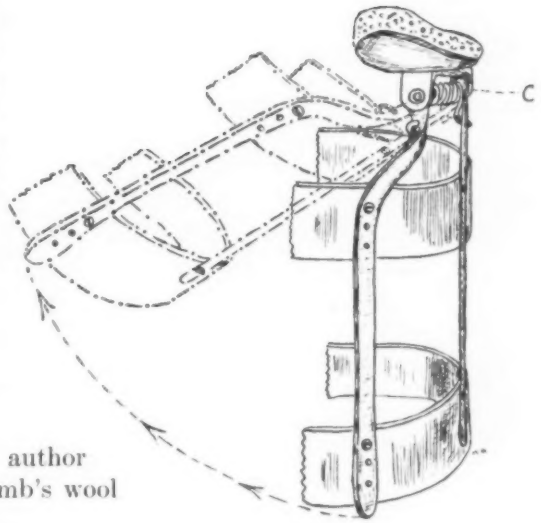


FIG. 2

The articulated seat is illustrated, showing the manner in which the brace flexes anteriorly under the seat in the sitting posture. The coil spring *C* is so articulated that it tends to maintain the seat in position for the standing posture and, when the patient sits, the brace flexes against the moderate spring tension.

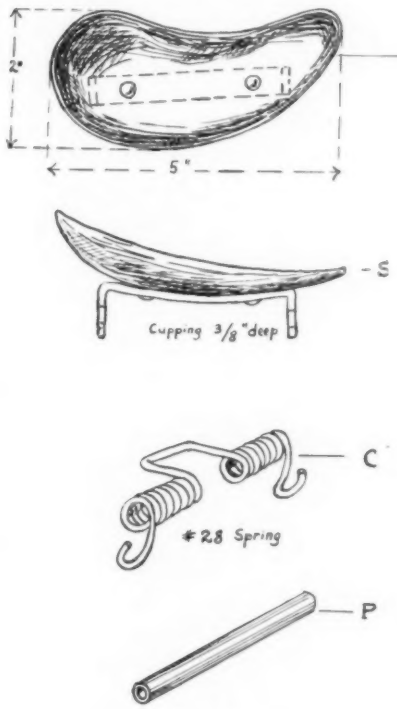


FIG. 3

Illustrating the component parts of the articulated seat. The dimensions of a seat for an adult of average size are indicated. The form of the coil spring *C* is shown. By means of the pin *P*, the spring is articulated with the ischial seat and the extension bars of the brace.

FIG. 4

Photograph of ischial seat in use on a patient with delayed union of a fracture of the shaft of the femur. Note the position of the seat under the ischium. The brace is articulated with a pelvic band.

The seat can be applied to any type of lower-extremity brace, whether a caliper into the shoe, a foot plate, or a patten is used. The device may be used with or without a pelvic band, which is very easily adjusted to this type of brace.

The ischial seat may be made in two distinct types. In the first type, which is the less expensive and the simpler, the seat (Fig. 1, *S*) is riveted to the two supporting bars. This form has the slight disadvantage that when the patient sits down he, of necessity, seats himself on the edge of the saddle. Most patients have experienced no discomfort from this fact, but, in order to overcome this difficulty in the more sensitive individuals, the author has articulated the seat with the two uprights in such a manner that it is capable of rotating around its transverse axis, so that its broad concave surface will face the ischium in either the sitting or the standing posture of the patient (Fig. 2). The rotation of the seat is controlled by means of a coil spring (Figs. 2, *C* and 3, *C*), which maintains the seat normally in the position for standing. The weight of the patient, as he seats himself, maintains a horizontal position of the seat under the ischium. The spring action returns the ischial seat to its normal relative position as soon as the patient arises from the sitting position. This articulated seat is more difficult to construct than is the rigid seat, and is by no means essential to the efficacy of the brace.

There are a number of advantages to the ischial seat in contrast to the Thomas ring. It provides a weight-bearing zone which can be easily and accurately adjusted to the ischium. It eliminates the disturbing pressure of the Thomas ring in the adductor area, a pressure which is difficult to overcome completely. It avoids the bulge which is visible through the clothing laterally where the ring is attached to the external longitudinal bar of the brace. It can be easily applied in double braces without having the seat on one side interfere with that of the other. It may be noted that the use of bilateral Thomas ring-braces is extremely difficult because the rings interfere with each other in the perineum.

SUMMARY

The substitute for the Thomas ring herein presented provides an easily adjustable ischial support which is comfortable and effective. It can be made by any competent bracemaker, and the expense to the patient should be not much more than that of the usual Thomas type of brace.

A NEW PLASTER-OF-PARIS CUTTER *

BY JOSEPH K. NARAT, M.D., CHICAGO, ILLINOIS

A search in the United States Patent Office has disclosed over 100 patents for plaster cutters. The abundance of such devices proves their inadequacy. Most satisfactory results seem to be obtainable from apparatus representing modifications of electric routers. The Leech-Beattie cutter may be considered as the representative of this group. Its disadvantage lies in the necessity of modifying the technique of application of the cast: a core must be placed between the stockinet, or sheet-wadding, and the plaster-of-Paris bandage. Withdrawal of this core from the cast leaves a channel for the cutter.

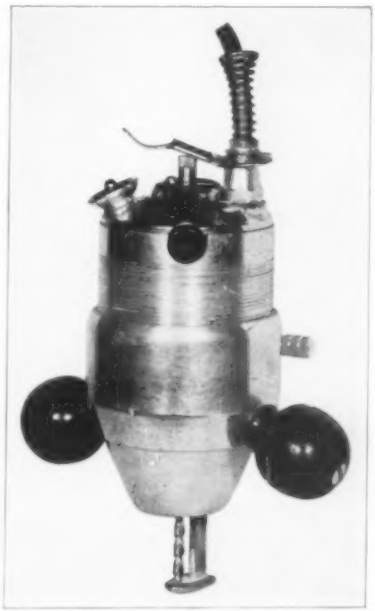


FIG. 1

The following modification of a routing machine, which has been worked out by the author with the help of a mechanic, has been found extremely handy for cutting plaster casts.

The portable router is a one-seventh horse-power unit, operating at 18,000 revolutions per minute. The motor is a universal type operating either on direct or alternating current. The diameter of the motor is three inches, the length six inches, and the weight three and one-half pounds. The unit has a patented forced-air-cooling system, which keeps the motor cool under continuous use. Special ball bearings are mounted on each end of the armature to accommodate the high speed. The housing is of strong aluminum alloy, highly polished, and the unit uses a collet type of chuck with a quarter-inch capacity. The motor unit is threaded sixteen threads to the inch to fit the threads in the router base, and turns the motor to the right or left, raising or lowering it,—giving the motor the proper depth adjustment.

Instead of the trigger found in similar devices, the switch has been placed directly on the housing of the motor to which a pair of handles is attached. This arrangement gives a better control of the apparatus.

In comparison with similar devices, this cutter offers the great advantage that it does not require any core; in other words, the usual technique of applying a cast can be employed. The apparatus is powerful

* Demonstrated at the meeting of the Chicago Orthopaedic Club, April 10, 1936.

enough to cut not only the plaster but also any of the customary reenforcements, such as basket splints, flexible metal strips, etc. As the router is protected with a so called shoe, and as the direction of the cutting is not toward the injured limb but parallel with its surface, the danger of trauma is excluded.

A PELVIC-BAND LEG BRACE WITH TWO-WAY MOTION AT THE HIP

BY EDWIN F. PATTON, M.D., LOS ANGELES, CALIFORNIA

From the Clinic of the Los Angeles Orthopaedic Hospital

In leg conditions in which a fixing point above the hip is needed for bracing, and in which flexion and abduction of the hip are permissible, the brace here presented is advantageous.

The principle of allowing lateral motion in addition to the usual forward and backward motion at the hip obviates the necessity of frequent repairs, due to the ripping out of pelvic-band rivets or the wrenching of the hip joint in a brace in which lateral motion is not allowed for. In a bilateral stiff-knee brace, such lateral hinging also permits the patient to go up and down stairs by spreading the legs apart.

FIG. 1

The side action is gained by using an ordinary barn-door hinge as the upper end of the side bar, instead of the usual solid piece. Figures 1 and 2 illustrate the practical mechanics. There is no loss of desirable fixation as far as the lever arm of the brace is concerned.

FIG. 2

This appliance has been used after fusion of a knee and in treating bow legs and knock knees. It can be applied in cases in which internal or external rotation of the leg needs to be controlled.

ACUTE OSTEOMYELITIS OF THE SCAPULA (ACROMION PROCESS)

BY W. E. BROGDEN, M.D., CANTON, OHIO

The following case of acute osteomyelitis of the scapula is interesting for two reasons: first, because of its infrequent occurrence; and second, because of the etiological factor.

W. C., a male, aged sixteen years, was admitted to the Orthopaedic Service at Aultman Hospital on February 6, 1936. He complained of pain, swelling, and disability of the left shoulder following a chill twelve hours previously.

On December 15 the patient had sustained a fall on the left shoulder while playing basketball. No treatment had been instituted and recovery was thought complete until January 15, 1936. On this date, incision and drainage of a left axillary abscess had been performed. The sinus had continued to drain seropurulent material. Dressings had been changed daily and the sinus had nearly healed.

Physical examination revealed a patient who looked extremely ill. The temperature was 104.2 degrees; the pulse, 122; and respirations, 32. Examination of the left shoulder showed some redness and induration, which was most marked over the acromion process of the scapula. There was acute tenderness over this region. The axillary abscess was draining moderately.

The laboratory report was as follows: urinalysis, negative; leukocyte count, 21,100. Both the smear and the culture showed long-chained streptococci.

Roentgenographic examination showed an osteomyelitic process involving the acromion process of the left scapula, with cloudiness of the lateral third of the clavicle and the epiphysis of the humeral head. Roentgenographic examination of the left shoulder on January 15 was negative for bone involvement.

Under general anaesthesia, an incision was made along the outer third of the clavicle, across the acromioclavicular articulation and acromion. No purulent material was encountered in this region. Arthrotomy of the shoulder joint with an aspirating needle revealed nothing. The periosteum was incised and retracted. Sequestrectomy was performed on the acromion process of the scapula, and drill holes were placed in the outer third of the clavicle. The bone both of the acromion and of the clavicle was soft and spongy, and a small amount of pus was present. The entire wound was packed open with vaseline gauze. The axillary abscess was explored and evacuated, and approximately half a pint of purulent material was obtained. A Velpeau dressing was then applied.

Twelve hours after the operation, the temperature was 99.6; the pulse, 115; and respiration, 22. The following day the temperature rose to 101 and then dropped to normal where it remained.

On February 8 the dressing was changed, and active motion was permitted. Three weeks later the axillary abscess had entirely healed. Five weeks later the wound on the left shoulder had entirely healed. Ten weeks after the operation the wounds had healed and function of the left shoulder joint was normal.

No doubt the osteomyelitis was the direct result of an improperly drained axillary abscess, and the avenue of infection was the blood stream as no contiguous channel between the abscess and the acromion could be demonstrated. The radical evacuation of the abscess facilitated to a great degree complete recovery and cessation of the osteomyelitic process.

A TRACTION SLEEVE

BY ROBERT T. FINDLAY, M.D., F.A.C.S., NEW YORK, N. Y.

This is a brief description of an article used in the treatment of fractures, which has been thoroughly and successfully tried out on patients in the ambulance of the Beekman Street Hospital in the City of New York during the past three years.

The traction sleeve is an adjustable, one-piece apparatus for application to standard metal splints (Murray-Jones hinged arm splint and Thomas half-ring leg splint) in the treatment of fractures of the extremities at the site of accident and during transportation to a hospital. In conjunction with the splint, the sleeve accomplishes *immobilization*, *traction*, and *suspension* of the injured part. It is considered an improvement over the various methods now in use with the same splints, for the same purpose.

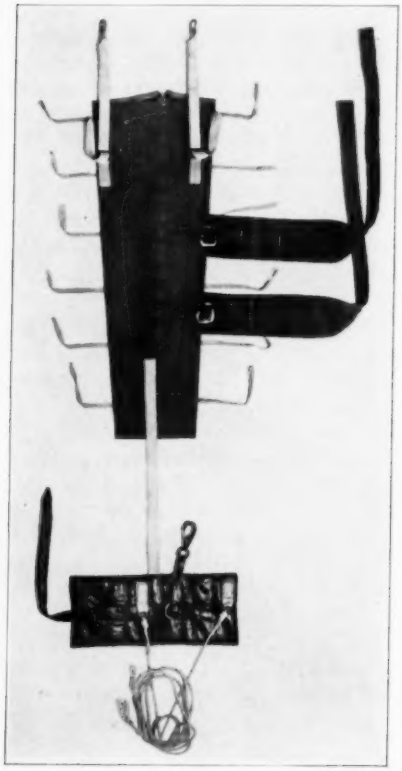


FIG. 1

Figure 1 shows the traction sleeve as a one-piece article, ready for use. The sleeve part is made of heavy sail canvas with a zipper in back. The only purpose of the zipper is to change the canvas to one thickness for scrubbing. When the canvas is opened out to one thickness, it measures twenty-one inches at the top, thirteen inches at the bottom, and thirty inches at the sides. The sleeve slides over the metal rods of the splint (Fig. 2) and, without adjustment, fits the largest size standard leg splint. The two tapes extending upward at the top of the sleeve (Fig. 1) are web tapes, one inch wide and fifteen inches long. These tapes are equipped with adjusting buckles at the bottom and halter clips, with holes one-half an inch in diameter, at the top. These clips fasten to rings at the joints of the splints* and they prevent the sleeve from slipping distally on the splint when the injured extremity is riding on it. The six

* These rings, one on each side, are sewed to the leather ring at the joint of both standard leg and arm splints. There is also added a one-inch web strap, with a two-way buckle, at the top of the leg splint, which straps across the upper thigh. (See Figure 2.)

FIG. 2

small tapes coming from the back on each side are half an inch in width and eight inches in length, and are placed five inches apart. These are used to tie across in back in adjusting the width of the sleeve to the width of the splint. The length of the sleeve is adjusted by tucking in the top and the bottom. When tucked in to its full extent—to the attachment of the two one-inch web straps at the top and the one-inch web strap in the center at the bottom—the sleeve fits the smallest standard arm splint.

The two large straps, extending from the right-hand side of the sleeve (Fig. 1), are of heavy canvas with buckles and holes, and fasten completely around the extremity and the splint, above and below the elbow or knee (Fig. 2). Each strap is thirty-three inches long and three and three-fourths inches wide at the buckle and tapers down to the width of the buckle at the holes. There are sixteen holes in each strap, one inch apart, and reenforced with metal. The straps are fastened to the main canvas with metal snappers and are adjustable up and down.

The tape which extends from the center of the lower portion of the sleeve is a one-inch web tape, eighteen inches long, and holds the main canvas to the leather piece below. This is merely to keep the apparatus in one piece. The oblong part, shown near the bottom of Figure 1 (fastened around the patient's ankle in Figure 2), is made of heavy, felt-lined soft leather, fifteen inches by six inches, with a one-inch leather belt attached to the middle. This is to be applied as a secure cuff around wrist or ankle. Attached to the leather cuff by a metal ring and webbing, in positions corresponding to each side of the wrist or ankle, are two strands of clothesline, sixty inches long, which are tied to the end of the splint and which continue for suspension of the splinted extremity.

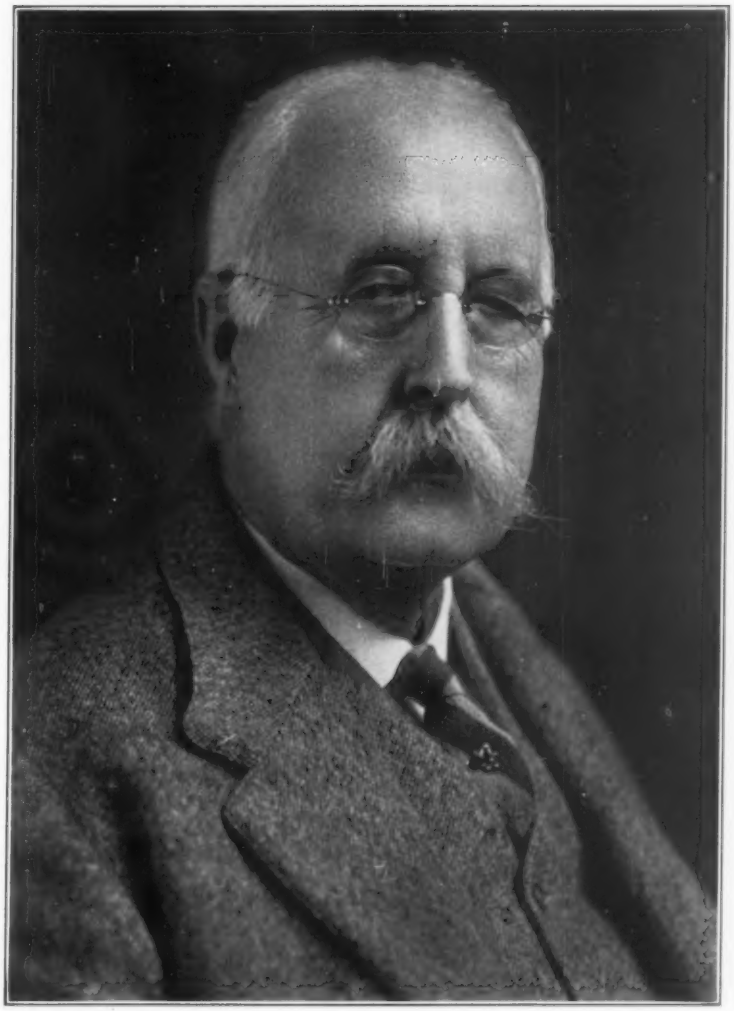
The "winder", which is attached for safe keeping to the buckle of the belt of the cuff in Figure 1 and is seen between the distal end of the sleeve and the end of the splint in Figure 2, is made of two ringed halter clips (with holes one-half an inch in diameter), which are held together with a ring of heavy leather in the center, so that the winder will bend in any direction and adjust its own width. This is placed between the two

strands of clothesline and wound as a Spanish windlass to obtain traction; it is then clamped to the rods of the splint.

CONCLUSIONS

The traction sleeve is washable, non-shrinkable, and nearly indestructible. Several advantages of the sleeve method over other forms of emergency traction have been observed:

1. It is more comfortable to the patient.
2. It may be applied more quickly and gently.
3. It requires less experience and training for its application.
4. It provides even pressure underneath the injured extremity. There is no undue sagging.
5. It does not slip distally on the splint.
6. It is adjustable to either arm or leg splint of any standard size.
7. It is made in one piece, is compact, and the parts are not easily mislaid.
8. Its appearance is neater than most other types of emergency traction apparatus.
9. It is possibly more economical in the long run.



JOHN RIDLON

1852–1936

On April 29, 1936 the American Orthopaedic Association lost its oldest and one of its most distinguished members in the death of Dr. John Ridlon at the Newport Hospital, Newport, Rhode Island. He was eighty-three years old and the only surviving member of the little group of fourteen who met at Dr. Newton M. Shaffer's house in New York in January 1887 to organize the American Orthopaedic Association.

His boyhood was spent on his father's farm in Clarendon, Vermont. He entered Tufts College where, after two years, he was expelled for a misdeed of his room-mate, but truth prevailed and in 1899 Tufts awarded him the honorary degree of Master of Arts and in 1926 the degree of Doctor of Science. After leaving Tufts, Dr. Ridlon went to the University of Chicago where he graduated in 1875. Having decided upon Medicine as a career, he graduated in 1878 from the College of Physicians and Surgeons of

Columbia University, New York, and in the same year he received the degree of Master of Arts from the University of Chicago.

Dr. Ridlon served as intern at St. Luke's Hospital, New York, from 1878 to 1880. He was then appointed Assistant Attending Orthopaedic Surgeon at the New York Orthopaedic Dispensary and Hospital, and Instructor in Orthopaedic Surgery at the New York University Medical School. He was also a surgeon of the First Orthopaedic Division of the Out-Patient Department of Bellevue Hospital, and Assistant at the Vanderbilt Clinic.

On June 4, 1879, he married Emily Caroline Robinson of Newport, Rhode Island.

In 1891 he moved to Chicago, where he became Professor of Orthopaedic Surgery in Northwestern University Medical School, a position which he held until 1908. From 1908 until 1911 he was Professor of Orthopaedic Surgery at Rush Medical College of the University of Chicago. He was also Professor of Orthopaedic Surgery at the Woman's Medical School of Northwestern University and at the Chicago Post-Graduate Medical School.

At the same time he was Attending Orthopaedic Surgeon at St. Luke's Hospital and Michael Reese Hospital, the Home for Destitute Crippled Children, and the Convalescent Home for Crippled Children of which he was one of the founders. He was also active in establishing the Jesse Spaulding School for Crippled Children, now one of the outstanding institutions of its kind in the world.

From the founding of the American Orthopaedic Association in 1887 until his retirement in 1929, Dr. Ridlon was one of the most outstanding and devoted members of that body. He was elected Secretary in 1890 and President in 1894. He was again elected Secretary in 1895 and served in that capacity until 1906. He rarely, if ever, missed a meeting of the Association up to the time when he moved to Newport.

Dr. Ridlon entered the Military Service in 1917 as orthopaedic instructor, and served at various posts. In January 1918 he organized the School of Instruction for Orthopaedic Medical Officers in Chicago. The teaching which he supervised was carried out at the various medical schools and hospitals. When the course was finished in the summer of 1918, he carried on orthopaedic instruction in the Army Medical School at Camp Greenleaf and other posts until the Armistice.

About seven years ago Dr. Ridlon moved to his summer home in Newport, Rhode Island, to live permanently. He was then active for the first five years and did consulting work at the Newport Hospital and the Newport Naval Hospital. At the latter institution he suggested to the Commandant the advisability of a weekly consultation visit, and continued this activity for some time.

He also interested himself in the affairs of the American Legion and gave freely of his time and effort to the veterans' problems. An examination of all the school children of Newport for faulty posture was an outstanding instance of his energy at the age of eighty. During this period he was a fairly regular attendant at the meetings of the Boston Orthopaedic Club and of the Rhode Island Medical Society. At one of the meetings of the latter society he presented an excellent paper on congenital dislocation of the hip, discussing the subject from all angles with a comprehensive differential diagnosis. About three years ago he was elected President of the Newport Medical Society and served for one year. He carried on a large correspondence and worked each day diligently on his memoirs.

His contributions to the literature of Orthopaedic Surgery consist of about 125 articles, but he will probably be best remembered for his writings on congenital dislocation of the hip, through which he made a real contribution to the subject.

A visit which Dr. Ridlon made to Hugh Owen Thomas in 1887 at Liverpool resulted in lifelong friendships with Mr. Thomas and with his nephew, Robert Jones. He was very deeply impressed with the soundness of Thomas' views regarding diseased joints and the necessity for rest in their treatment, and he remained a most ardent advocate and teacher of those principles all his life. In 1899 he collaborated with Sir Robert Jones in a treatise on Orthopaedic Surgery, in which the writings and teachings of Hugh Owen

Thomas were more fully elaborated, and "modified by their own personal experience and convictions". It is a little volume which would well repay the reading by every young orthopaedic surgeon of today.

Dr. Ridlon was a man of great energy, and an indefatigable worker, with the necessary patience to follow out the most obstinate cases with unflagging interest, and he was always trying to work out a better method for securing the results which he felt should be obtained.

He was given to thinking straight and reasoning logically, and when he had come to a conclusion he was ready to defend it against all comers. With his striking and dominant personality, this brought him into argumentative conflict with some of his confrères, but without resentment or animosity. His gift for teaching objectively and the thoroughness of his work always secured the interest and admiration of his students and assistants. The most loyal and devoted of his lifelong friends were those who had been associated with him in his clinical teaching and private practice and had had an opportunity to know the man as well as the teacher. He had the gift of being able to stimulate the interest and enthusiasm of the younger men who came under his influence, and many of the men who in later years have achieved prominence in Orthopaedic Surgery, especially those in the Middle West, owe much of their success to the encouragement, advice, and inspiration which they received from him. Not only to the members of the American Orthopaedic Association, but also to his many professional friends of the younger generation elsewhere, he was affectionately known as "Uncle John". In his death we have lost a great member of our profession.

News Notes

The Fiftieth Annual Meeting of the **American Orthopaedic Association** was held in Milwaukee, Wisconsin, at the Hotel Schroeder on May 18 to 21, under the presidency of Dr. Frederick J. Gaenslen.

The first day was a clinical day, and cases were presented by Dr. Gaenslen and his associates in Milwaukee. A golf tournament was held on the afternoon of the first day. The remaining portion of the Meeting was given over to the presentation of papers, as follows:

TUESDAY, MAY 19

Morning Session

President's Address.
Dr. Frederick J. Gaenslen, Milwaukee, Wisconsin.

History of Fracture Treatment.
Dr. William Arthur Clark, Pasadena, California.

New Operative Procedure for Instability of the Knee Joint.
Dr. H. Page Mauck, Richmond, Virginia.

Treatment of Intercondylar Fractures of the Elbow Joint with Skeletal Traction.
Dr. Rudolph S. Reich, Cleveland, Ohio.

Fractures and Fracture-Dislocation of the Cervical Spine.
Dr. William G. Turner, Montreal, Canada.
Dr. William Cone, Montreal, Canada.

Afternoon Session

Fractures of the Acetabulum with Subluxation of the Hip.
Dr. Willis C. Campbell, Memphis, Tennessee.

Series of Fractures of the Neck of the Femur, United with Excellent Functional Results after Treatment by Means of Smith-Petersen Nail.
Dr. Lawson Thornton, Atlanta, Georgia.
Dr. Calvin Sandison, Atlanta, Georgia. (By invitation.)

Inclination of the Pelvis and Acetabulum as a Causative Factor in Slipped Epiphysis and Non-Union in Fractured Hips.
Dr. Lloyd T. Brown, Boston, Massachusetts.

Analysis of Results of Early Treatment of Congenital Dislocation of the Hip by Manipulation and Osteoclasis for Anterior Distortion.
Dr. Arthur Krida, New York, N. Y.
Dr. Paul Colonna, New York, N. Y.
Dr. Francis J. Carr, Jr., New York, N. Y. (By invitation.)

WEDNESDAY, MAY 20

Morning Session

Septic Hips: A Study of End Results.
Dr. Carl E. Badgley, Ann Arbor, Michigan.

Acute Osteomyelitis. Treatment in the Light of Recent Serological Findings. (Read by title.)
Dr. D. E. Robertson, Toronto, Canada.

Primary Point of Infection in Tuberculosis of the Hip.
Dr. Dallas B. Phemister, Chicago, Illinois.
Dr. C. Howard Hatcher, Chicago, Illinois. (By invitation.)

The Occurrence of Abscesses from Hips That Are Firmly Ankylosed.
Dr. Z. B. Adams, Boston, Massachusetts.
Treatment of Bursitis.
Dr. M. N. Smith-Petersen, Boston, Massachusetts.
Dr. Paul Norton, Boston, Massachusetts. (By invitation.)
Bone Metabolism.
Dr. A. Bruce Gill, Philadelphia, Pennsylvania.
Dr. Irvin Stein, Philadelphia, Pennsylvania. (By invitation.)

Afternoon Session

Wave Mechanics of Muscle Motion.
Dr. Eben J. Carey, Milwaukee, Wisconsin. (By invitation.)
Fascial Transplants in Infantile Paralysis and Other Conditions Involving Weakness of the Muscle Groups.
Dr. Frank Dickson, Kansas City, Missouri.
Correction of Paralytic Drop-Foot by Tendon Transplantation.
Dr. Leo Mayer, New York, N. Y.
Factors Influencing the Balance of the Foot in Walking.
Dr. R. Plato Schwartz, Rochester, New York.

THURSDAY, MAY 21

Morning Session

An Inquiry on Articular Pain.
Dr. J. G. Kuhns, Boston, Massachusetts.
Dr. H. L. Weatherford, Boston, Massachusetts. (By invitation.)
Auscultation of Joints.
Dr. Arthur Steindler, Iowa City, Iowa.
Chronic Atrophic Arthritis.
Dr. Theodore A. Willis, Cleveland, Ohio.
Treatment of Giant-Cell Bone Tumors.
Dr. H. W. Meyerding, Rochester, Minnesota.
Arthrotomies for Internal Derangement of the Knee Joint. (Read by title.)
Dr. Paul P. Swett, Hartford, Connecticut.

The Annual Dinner was held on Wednesday evening, May 20, at The Wisconsin Club.

At the Executive Session held on May 19, the following were elected to membership:
Dr. Mather Cleveland, New York, N. Y.
Dr. Joseph E. Milgram, New York, N. Y.
Dr. Alan DeF. Smith, New York, N. Y.
Dr. W. E. Wolcott, Des Moines, Iowa.

The officers for the ensuing year are:
President: Dr. H. Winnett Orr, Lincoln, Nebraska.
President-Elect: Dr. Frederick C. Kidner, Detroit, Michigan.
Vice-President: Dr. William G. Turner, Montreal, Canada.
Treasurer: Dr. John L. Porter, Evanston, Illinois.
Secretary: Dr. Ralph K. Ghormley, Rochester, Minnesota.
Member of Membership Committee: Dr. Philip D. Wilson, New York, N. Y.
Member of Program Committee: Dr. Carl E. Badgley, Ann Arbor, Michigan.
Delegate to The American College of Surgeons: Dr. W. C. Campbell, Memphis, Tennessee.
Delegate to The American Board of Orthopaedic Surgery: Dr. M. S. Henderson, Rochester, Minnesota.

The next Meeting will be held in Lincoln, Nebraska, under the presidency of Dr. H. Winnett Orr.

The Spring Meeting of the **British Orthopaedic Association,** under the presidency of Mr. W. R. Bristow, was held from April 22 to 26 in Brussels at the invitation of the Belgian Surgical and Orthopaedic Societies, who met under the presidencies of Dr. Huston and Dr. Van Haelst.

The three days were spent in visiting the orthopaedic and surgical clinics of Brussels and in discussing various orthopaedic subjects. The main subject was introduced by Prof. Parisel who, with Dr. Serbzt, presented a report on "Apophysitis of the Tibial Tubercle (Osgood-Schlatter Disease)". In the discussions which followed no new light was thrown on its pathogenesis. It was generally agreed that: (1) trauma plays an exciting rôle, possibly by interference with the blood supply of the growing tibial tubercle; (2) adequate treatment consists in the avoidance of overstrain during the active phase of the "disease". In exceptional cases operation may be necessary for the removal of troublesome calcareous deposits in the region of the tubercle.

The following short communications were also presented:

Osteosynthesis of Transverse Fractures of the Femoral Shaft.
Prof. J. Verbrugge (Anvers).

Some Operations of Reparative Surgery.
Prof. Dehez (Liége).

Congenital Elevation of the Scapula.
Prof. Maffei (Brussels).

Some Roentgenograms of Congenital Dislocations of the Hip.
Prof. Maffei (Brussels).

Trial of Surgical Treatment for the Prevention of Deformity in Adolescent Coxa Vara.
Prof. Delchef (Brussels).

Epidural Lipiodol Exploration in Spina Bifida Occulta.
Prof. Delchef (Brussels).

The Association Dinner was held in *La Taverne Royale;* the Presidents and members of the Committee of the Belgian Societies were the guests of the Association.

The Ladies' Committee of the Belgian Societies had arranged tours in and around the city, which were keenly enjoyed by the visiting ladies.

The Annual Meeting of the **British Orthopaedic Association,** will be held in London on October 30 and 31, 1936, under the presidency of Mr. W. R. Bristow.

The First Congress of the **Sociedad Española de Cirugía Ortopédica y Traumatología** was held in Barcelona on June 19 to 22. The subjects chosen for discussion at this meeting were "The Pathology of Hydrarthrosis", "Medullary Compression in Pott's Disease", and "Operative Treatment of Recent Fractures of the Long Bones".

Dr. H. Earle Conwell announces his association with Dr. John D. Sherrill, 216–222 Medical Arts Building, Birmingham, Alabama.

The First **International Congress of Sanatoria and Private Nursing Homes** will be held in Budapest in the latter part of September 1936. Short abstracts of lectures, discussions, proposals, etc., should be sent as soon as possible to the Committee, Margitsziget Sanatorium, Budapest.

The **American Public Health Association** will convene in New Orleans, Louisiana, on October 20 to 23 for its Sixty-Fifth Annual Meeting. A report on the state of the nation in matters of public and personal health will be presented. The President-Elect of the Association is Dr. Thomas A. Parran, Jr., Surgeon General of the United States Public Health Service, and the Executive Secretary is Dr. Reginald M. Atwater. National headquarters of the Association are at 50 West 50th Street, New York, N. Y.

The **Deutsche Orthopädische Gesellschaft** will hold its next Congress in Königsberg Pr. on August 28, 29, and 30, under the presidency of Prof. Dr. Lothar Kreuz. On the first day the morning session will be devoted to discussions on "The Rôle of Orthopaedic Surgery in Congenital Deformities", and in the afternoon the subject to be considered will be "The Rôle of Orthopaedic Surgery in Hygiene". On the following days the papers to be presented will deal with: "The Knowledge and Treatment of Talipes Calcaneus", "The Biology of Amputations", "The Pathological and Clinical Considerations of Acute Lumbago", and "The Origin, Prevention, and Treatment of Ankylosis".

The Eighteenth Annual Meeting of the **Société Française d'Orthopédie** will take place in Paris on October 9 and 10, under the presidency of Prof. Le Fort. The questions to be considered are "Spondylolisthesis" and "Abnormal Callus of the Instep".

The Clinical Days of the **Société Française d'Orthopédie** will be held in Turin on September 18, 19, and 20, under the direction of Prof. Ugo Camera. The opening meeting will be held at the *Ospedale "Regina Margherita"*. At a session at the *Clinica Chirurgica*, Prof. Uffreduzzi will present cases and there will be demonstrations of technique, including surgery of the hip, treatment of inequality of leg length, treatment of the sequelae of poliomyelitis, treatment of congenital club-foot by tendon grafts, etc. An attractive program of excursions in Turin and the neighboring country has been arranged.

The First **International Conference on Fever Therapy,** originally scheduled for the end of September 1936, has been postponed to permit more time for the preparation of material. The new dates set for this Conference are March 30 to April 2, 1937. The sessions will be held at the College of Physicians and Surgeons, Columbia University, New York City. A tour has been arranged to take place immediately after the Conference to enable physicians to observe the techniques employed in fever therapy in some of the hospitals in the eastern section of the United States. Among the institutions to be visited are: the Strong Memorial Hospital of the University of Rochester, Rochester, New York; the Henry Ford Hospital, Detroit, Michigan; The Mayo Clinic, Rochester, Minnesota; the Kettering Institute for Medical Research at the Miami Valley Hospital, Dayton, Ohio; and Northwestern University Medical School, Chicago, Illinois. Further information regarding the Conference may be obtained from the General Secretary, Dr. William Bierman, 471 Park Avenue, New York, N. Y.

The **Sociedad Argentina de Cirugía Ortopédica,** which has just been founded in Buenos Aires, announces the election of the following officers:

Chairman: Dr. Luis A. Tamini
Vice-Chairman: Dr. José Valls
Secretary: Dr. Carlos E. Ottolenghi
Treasurer: Dr. Pedro H. Garavano

The Third Congress of the **International Society of Orthopaedic Surgery,** which is to be held in Bologna, Italy, will open on September 21 with a General Assembly. Prof. Vittorio Putti is the President of the Society and the President's Dinner will take place on the evening of the opening day. The next three days will be devoted to a presentation and discussion of papers. On the afternoon of September 24 the members will leave for Rome and on the next day they will have opportunity to visit the new Clinic of Orthopaedic Surgery in Rome and to observe various clinical demonstrations there. There will also be an exhibition at the *Istituto Rizzoli* to show the progress achieved in the surgery of the locomotor apparatus. This exposition will include a scientific section and a technical section.

The meeting of the **Orthopaedic Section of the American Medical Association** was held in Kansas City, Missouri, on May 13, 14, and 15. On the first afternoon the

Chairman, Dr. Arthur T. Legg, presented his address on "The Early Orthopaedic Treatment of Poliomyelitis". The rest of the first day was allotted to the papers and discussions on "Fractures of the Neck of the Femur".

On the second day there was a symposium on Osteomyelitis including "Growth Changes in Bone" and "Late Infection Due to the Use of Wire and Pins".

At the business session on May 15 the following officers were elected for the coming year: Dr. Fremont A. Chandler, Chairman; Dr. John Dunlop, Vice-Chairman; Dr. Robert V. Funsten, Secretary. Dr. J. S. Speed, Dr. Robert Schrock, and Dr. Arthur Legg were appointed to the Executive Committee. Dr. Henry W. Meyerding continues his appointment to the House of Delegates with Dr. Roland Hammond and Dr. J. S. Speed as alternates.

The remainder of the meeting was devoted to a general program including tuberculosis, bone-grafting, slipped femoral epiphysis, correction of faulty posture, and habitual dislocations of the shoulder.

At the annual meeting of the **Deutsche Gesellschaft für Unfallheilkunde, Versicherungs- und Versorgungsmedizin,** held in Berlin on October 18 and 19, 1935, the problems relative to some of the general questions of insurance, hygiene, heredity, and growth were discussed and papers were presented by Prof. Hübner (Berlin), Prof. Schmidt (Remscheid), Prof. Dersch (Berlin), Prof. Charlton (Berlin), Prof. Kuhr (Berlin), Prof. Zollinger (Zurich), Prof. Scholtze (Berlin), Prof. Weiler (Munich). Prof. Blencke (Magdeburg) and Prof. Thomsen (Frankfurt a.M.) discussed some of the questions pertaining to the type and use of apparatus employed in the treatment of orthopaedic and traumatic conditions and emphasized the need of more attention on the part of the surgeon in its application. Prof. Schmieden (Frankfurt a.M.) and Prof. Sauerbruch (Berlin) called attention to the importance of and gave suggestions in regard to the treatment of wounds about the thorax. Prof. Häbler (Würzburg) combatted the claim that the presence of metallic substances causes decomposition and atrophy of bone in osteosynthesis. Prof. Baader (Berlin) gave some of the results of the use of phosphorus in industry. Prof. Sommer (Dortmund) reported on some of the disturbances following the use of antitetanic serum. Prof. zur Verth discussed the difficult question of the desirable length of the stump in amputations of the leg below the knee. As a result of his experience, he believes that the stump should not be longer than one-half the length of the leg from the knee to the foot.

The next meeting will be held in Hamburg, September 17 and 18, 1936, under the presidency of Prof. Dr. M. zur Verth. The subjects to be considered are "Heredity and Constitution in Their Relation to Insurance" and "Injuries to the Meniscus". A most cordial invitation to attend this meeting is extended to the members of the American Orthopaedic Association and of the American Academy of Orthopaedic Surgeons.

The **Sociedade Brasileira de Orthopedia e Traumatologia** has recently been organized in São Paulo with the object of stimulating and perfecting the study and practice of orthopaedic and traumatic surgery. The Society has among its founders those surgeons who are specializing in these subjects, and its members decided to establish headquarters in São Paulo because of the development of the Orthopaedic School there. The Society plans to hold sessions regularly in the various states as well as in the central office. The annual meetings will be held in the capital of each state successively.

The officers elected at the organization meeting were:

President: Prof. Dr. Luiz de Rezende Puech
Vice-President: Dr. Domingos Define
General Secretary: Dr. Renato da Costa Bomfim
Assistant Secretaries: Dr. Itapema Alves and Dr. Odair Pedroso
Treasurer: Dr. Domingos M. Rezende
Librarian: Dr. Ulysses Barbuda

In addition to these, editorial and advisory committees were appointed.

The first annual meeting was held in June of this year under the presidency of Prof. Dr. Rezende Puech, and was attended by Dr. Vittorio Putti of the Italian Orthopaedic School in Bologna, and also by Brazilian members of the profession.

Prof. Putti spoke on "Orthopaedic Surgery in Contemporary Medicine" and showed that orthopaedic surgery as it has developed has come to include most of the surgery of the locomotor apparatus and that traumatology is, therefore, closely allied with it. Prof. Rezende Puech presented an excellent discussion on the question of "Anterior Tibiotarsal Arthrodesis by Bone Graft in the Treatment of Old Paralytic Talipes Calcaneus". Prof. Barros Lima contributed an interesting study on new aspects of the treatment of osteoarticular tuberculosis in Brazil.

During the closing session Prof. Vittorio Putti (Bologna), Dr. Fred Albee (New York), and Prof. Ombrédanne (Paris) were elected Honorary Members.

The next Congress will take place in Rio de Janeiro in July 1937, under Prof. Achilles de Araujo, the newly elected President. The following subjects have been chosen for discussion: "Congenital Dislocation of the Hip in Brazil" and "Fractures of the Neck of the Femur".

The First Congress of the **Ukrainian Society of Orthopaedic and Traumatic Surgery** took place on January 24 to 28, 1936, at Kharkov, U. S. S. R.

Since 1925, at each surgical congress one day has been allotted to the consideration of orthopaedic surgery. This time was filled with the discussion of important questions arising in orthopaedic and traumatic surgery, and the necessity of organizing a special congress finally became evident. Some difficulty was encountered in the final arrangements, but this year it was decided to call the First Congress of the Ukrainian Orthopaedic Surgeons. Four hundred orthopaedic surgeons from the different parts of the Union were present and the meeting acquired the character of an All-Union Congress. The committee in charge of the meeting was of the opinion that the First Congress should pay special attention to the question of organization.

The first day was devoted to questions which have an important bearing on orthopaedic surgery, such as the system of health preservation, medical education, fundamental principles of classification and registration in orthopaedic surgery, the necessity of uniform nomenclature, typical records of cases, orthopaedic prophylaxis for children, and types of orthopaedic institutions. Papers on these subjects were read by delegates from different parts of the Union. The question of the rôle which orthopaedic surgery should play in the matter of medical education called forth some controversy,—its place among other subjects, the question of the number of lectures to be assigned, and also whether trauma of the locomotor apparatus should be included under orthopaedic surgery. Special stress was laid on the importance of the uniformity of standards for the registration of orthopaedic patients.

The second day was devoted to the question of traumata of the locomotor apparatus. The principal subject on this program was injuries due to machine labor, and especial attention was paid to methods of reducing the frequency of these injuries. A series of reports dealt with cases of trauma occurring in street traffic. There were also a number of reports on methods of economizing the capacity for work which remains after diseases or injuries to the locomotor apparatus, and also on the use of prostheses for workmen.

On the third day the question of poliomyelitis was considered. Thirty reports were presented dealing with the conservative and the operative treatment of the consequences of poliomyelitis. A series of reports were devoted to the results of operative treatment, transplantation of tendons, astragalectomy and arthroereisis.

The fourth and last day was devoted to arthroplasty, and a number of orthopaedic surgeons presented their experience in dealing with this procedure.

At the same time an exhibition was arranged with interesting exhibits of different phases of orthopaedic work, which bore witness to the success of the young Soviet orthopaedic surgeons.

The next Congress will take place in 1937 in Leningrad.

Current Literature

DIE ORTHOPÄDISCHE WELTLITERATUR. Edited by Prof. Dr. August Blencke and Prof. Dr. Hermann Gocht. II. Band. Stuttgart, Ferdinand Enke, 1936. Two volumes, 196 marks, less a discount of 25 per cent. to purchasers outside of Germany.

The second of the two volumes of "Die orthopädische Weltliteratur", edited by Dr. Blencke and Dr. Gocht with the collaboration of a large number of very prominent orthopaedic surgeons in different parts of the world, has recently appeared. The first volume met a great need for a comprehensive collection of the world literature and included references to the general subjects connected with orthopaedic and traumatic surgery. The second volume is confined to subjects of distinct orthopaedic interest. The references are indexed under the authors' names in fifteen groups, so that the reader has easy access to the literature pertaining to the special subject in which he is interested. The grouping is as follows:

Deformities and Diseases of the Neck and Head;
Deformities and Diseases of the Thorax and Shoulder Girdle;
Posture, Malposture, Scoliosis, and Kyphosis;
Tuberculous Spondylitis;
Deformities and Diseases of the Spine; Back Pain and Lumbago;
Deformities and Diseases of the Upper Extremity;
Deformities and Diseases of the Pelvis and Ischium;
So Called Congenital Dislocation of the Hip;
Tuberculous Hip Disease and Its Sequelae;
Coxa Vara, Coxa Valga, Malum Coxae, and Other Diseases and Deformities of the Hip;
Genu Valgum, Genu Varum, and Genu Recurvatum;
Deformities and Diseases of the Upper and Lower Extremities and of the Knee Joint;
Pes Equinus, Equinovarus, and Various Deformities of the Foot;
Flatfoot, Pronated Foot, and Splayfoot;
Diseases and Deformities of the Joints of the Foot and of the Toes.

The more extensive interchange of medical and surgical studies from the different countries and the increasing contributions from many countries which a few years ago did not produce any appreciable amount of literature dealing with orthopaedic problems are factors which have played important rôles in making this volume a valuable addition to the library of the orthopaedic surgeon.

EMERGENCY SURGERY. By Hamilton Bailey, F. R. C. S. (Eng.). Baltimore, William Wood & Co., 1936. $14.00.

It is very appropriate that this excellent book should open with chapters on "Intravenous Infusion", "Blood Transfusions", "Anaesthesia for Urgent Operations", and "Armamentarium". This is a book on *emergency surgery*. Everything is short and to the point. In regard to the sterilization of the patient's skin, one sentence is enough: "The iodine preparation of the skin has stood the test of time, and for urgent cases it is unsurpassed."

When the various types of surgical operations are considered, the instruments needed are described and illustrated, the incisions to be used are shown, and in many instances the pathological conditions are illustrated in color. Pitfalls, complications, short cuts, and operative approaches are discussed briefly.

Abdominal and thoracic surgery receive by far the greatest amount of attention. The excellent chapters on bones and joints possibly are not complete enough. The treat-

ment of simple fractures is not mentioned. Compound fractures rate only a short chapter of ten pages.

Some of the procedures in the operative treatment of compound fractures are open to criticism. The paragraphs on the Carrel-Dakin method are good but inadequate. The Orr treatment is mentioned briefly for complications arising from compound fractures.

Dislocations assume their place in this volume and the usual manipulations for their reduction are indicated. The chapter is well illustrated. Aspiration and drainage of joints in acute suppurative arthritis are well described and illustrated. The chapters on "Nerves and Tendons", "Lacerations of the Hand", and "Infections of the Hand" are all good.

One of the best chapters in the book is the one on "Urgent Amputations". The text and the plates are well prepared. The important details of the best levels for amputation, the operative technique, and the application of artificial limbs are thoroughly described.

LES OSTÉOTOMIES SOUS-TROCHANTÉRIENNES DANS LE TRAITEMENT DES LUXATIONS CONGÉNITALES INVÉTÉRÉES DE LA HANCHE. By Pierre-Marcel Lance. With a Preface by Pr. Ombrédanne. Paris, Masson et C^ie^, 1936. 30 francs.

The author states that the experience of the last few years with osteotomies has been sufficient to warrant the deduction of the indications and the development of a safe and sure technique. In this book he confines his study to the subject of subtrochanteric osteotomy, with particular attention to the bifurcation operation of Lorenz. He gives an excellent description of the pathological anatomy both of the bones and of the muscles which are associated with malposition of the pelvis, etc.

In this book osteotomies are divided into two groups: those performed with the object of changing the direction of the femur, and those done to give pelvic support. In considering the first group, the author reviews the various methods and types of osteotomies, beginning with that advocated by Kirmisson. He discusses the indications and also the problems which may arise in connection with this operation. Many cases are cited to illustrate the various deformities for which this procedure is indicated.

In discussing the second group, the author considers in detail the bifurcation operation of Lorenz, including a short review of its first use, its reception, and its employment in the early years. He then discusses the defects and failures of this operation and of other forms of osteotomy and the general considerations which must be borne in mind in the employment of subtrochanteric osteotomies performed with the object of giving pelvic support. He next reviews the anatomical and mechanical factors in order to explain the defects of this operation which places the upper end of the lower fragment in the imperfect acetabulum, a practice which he considers to be unsound and frequently unsatisfactory. The advantages and disadvantages of this method are discussed in detail, and the author is distinctly in favor of its modification. One of the most important results of the modified method is the very satisfactory correction of the tilting of the pelvis.

The high osteotomy of Froelich and the low osteotomy of Schanz are discussed and compared with the usual methods of osteotomy. Cases are cited which illustrate the conditions in which these methods are used and the results, both favorable and unfavorable, are given.

The criticisms which the author makes in regard to the various methods are accompanied by suggestions as to the procedures which may be employed to meet the objections. The different methods which are described are illustrated by cases and excellent roentgenograms. Not only are the favorable results given, but the failures are also included, with the reasons for failure in many cases. The book is well illustrated with photographs, roentgenograms, and drawings, and a very comprehensive bibliography is appended.

AMERICAN MARTYRS TO SCIENCE THROUGH THE ROENTGEN RAYS. By Percy Brown, M.D., F.A.C.P., F.A.C.R. Springfield, Illinois, Charles C. Thomas, 1936. $3.50.

In this book Dr. Brown pays tribute to the pioneers who sacrificed themselves in the early development of the use of the roentgen ray and who, by that sacrifice, gave to mankind one of the most signal benefits of modern times. Dr. Brown, himself a pioneer, is well equipped for this task and has given a presentation which is evidently the result of a labor of love.

Preceding the biographies of the representatives of this group, which is confined to American roentgenologists, Dr. Brown furnishes the reader with an interesting historical sketch of some of the more important and interesting phases in the development of this therapeutic agent and of the difficulties which these pioneers were obliged to overcome. Also included is a history of the long period in which these men were subjected to the dangers of the roentgen ray before these dangers were recognized, and of the still longer period before adequate protection was afforded these operators. This portion of the book is also full of interesting information on the mechanical and scientific as well as the clinical work which was necessary for the development of this specialty in the early days before the value of the roentgen ray had received adequate recognition. The author emphasizes the enthusiasm of the pioneers for their work and their belief at that time in the future of their specialty.

Dr. Brown pays tribute to each of the men whose biographies appear in this volume, and his personal contact with a large number of them enabled him to portray much of their characters which otherwise would have remained unrevealed. In the discussion of their lives he has included the special contribution which each has made to the development of the roentgen ray.

It is fortunate that Dr. Brown was prompted to perpetuate in this way the record of the sacrifice which these men have made in their contributions to this branch of medicine. The reader will find the book extremely interesting, and the personal element, which is evident throughout, adds very materially to its attractiveness.

DIE NACHBEHANDLUNG NACH OPERATIONEN. By Prof. Dr. Paul Reichel. 3. Aufl. Berlin, Julius Springer, 1936. 25.80 marks.

The first edition of Prof. Reichel's book on postoperative treatment was published in 1896. The third edition, which has just been issued, is based on more than thirty years' experience as the director of a large Surgical Service. The subject of postoperative care has not always received the attention which is due so important a part of the treatment; operative technique has attracted the greater attention. It is encouraging, therefore, to see that the field is being covered and that the demand for expert information has resulted in this third revised and enlarged edition.

This book covers the entire field of surgery. The larger portion is devoted to general surgery, but there is a very generous section given up to subjects bearing on orthopaedic and traumatic surgery. The subjects are considered under the regional grouping,—the spine and the upper and lower extremities. The treatment of most of the orthopaedic and many of the traumatic cases necessarily includes the use of apparatus, and many kinds of apparatus are described and illustrated. The tendency to adhere to some of the older and well-established types is evident. This conservative attitude is most commendable.

As the author states in the preface, the book is not written for the experienced surgeon. It is intended for the younger surgeon and general practitioner, and to them it will be of great value.

LES TUMEURS PRIMITIVES DU RACHIS. CHIRURGIE DU CORPS VERTÉBRAL. By J. Boudreaux. Paris, Vigot Frères, 1936. 45 francs.

The author calls attention to the fact that the primary tumors of the spine have always been regarded as rather unusual and have not received sufficient attention. The

work of Schlesinger, which appeared in 1898 and which marked an epoch in the understanding of vertebral tumors, served as a basis for subsequent studies which have demonstrated the importance of primary tumors. With the development of accurate facilities for investigation and study, it is now advisable to rearrange the grouping of the primary vertebral tumors with the special object of establishing identification by the evidence given by the x-ray and pathological anatomy. The author has found this task rather difficult because of the imperfect reports included in the literature of the earlier years.

In treating this subject, the author has divided the book into four parts. The first is a consideration of the malignant tumors, including myelomata, Ewing's sarcomata, osteosarcomata, chondrosarcomata, fibrosarcomata, and chordomata; the second is a discussion of benign tumors, among which are myeloplaxomata, angiomata, chondromata, osteomata, lipomata, fibromata, and solitary cysts; the third is devoted to diagnosis of the primary tumors; and the fourth is concerned with treatment.

Each group is carefully discussed with reference to the etiology, structural pathology, occurrence, growth, clinical characteristics, etc., and it is from this study that the author has made his classification of these primary tumors. Each type is illustrated by typical cases, and there are some excellent roentgenograms. It is to be regretted that the author has not more fully illustrated the different types of tumors, but those which are presented are very convincing.

The diagnosis of these primary tumors is discussed from the clinical and roentgenographic aspects and with relation to the primary and secondary occurrences and the malignancy and benignancy, and also with reference to the other pathological affections which are found in the spine. Diagnosis depends largely on the clinical and roentgenographic characteristics, and the author is evidently strongly in favor of exploratory biopsy as a routine supplementary procedure.

In the portion of the book which is devoted to treatment, the reader will find a great deal of suggestive information to aid in deciding upon and carrying out the method of treatment. The use and effect of radiotherapy on each group is given, as well as the results which may be expected from it. In the discussion of the surgery of these tumors, the various approaches to the different regions are very carefully described and the anatomy is illustrated by diagrams.

HANDBOOK OF SURGERY. By Eric C. Mekie, M.B., Ch.B., F.R.C.S. (Edin.). With a Foreword by John Fraser, M.C., M.D., Ch.M., F.R.C.S.E. Baltimore, William Wood & Co., 1936. $4.50.

In the preface Mr. Mekie states that this book has been written primarily for undergraduates in an attempt to give them the irreducible minimum of surgical knowledge in order to pass the final examinations in surgery.

A glance through the table of contents and a rather careful reading of the chapters concerning bone and joint disabilities would suggest that the author has succeeded very well in his purpose. Each subject, although treated briefly, contains the essentials concerning the clinical features, course, and treatment. In a volume of this size it is, of course, impossible to give more than the barest outline of the multitude of surgical conditions now recognized. The reviewer feels that most students would be benefited more by a study of one of the larger text-books of surgery, even though they were unable to cover as much ground in the process. The mere reading of a compendium is usually not productive of a clear-cut conception of a disease process. Because of limitation of space presumably, there are very few illustrations and these are diagrammatic. As is usual in first editions, minor faults are frequently encountered which will doubtless be corrected in later editions.

It is rather evident that the volume is not for post-graduate use, at least primarily, and it is probably true that undergraduates in the United States will seek most of their information from American authors. The English undergraduate will probably find the volume of real service in preparation for his examinations.

ORTHOPÄDISCHE APPARATE UND BANDAGEN AUS KLINIK UND WERKSTATT (Orthopaedic Braces and Appliances from Clinic and Workshop). By Prof. Dr. Georg Hohmann. Beilageheft zur *Zeitschrift für orthopädische Chirurgie*, LXIV, 1936. Stuttgart, Ferdinand Enke, 1936. 7.50 marks.

The value of close cooperation between the orthopaedic surgeon and the brace-maker is beautifully illustrated by this monograph of seventy-two pages. Old principles are utilized in new ways to produce some valuable appliances. The description of Dr. Hohmann's hip splint for malum coxae, pseudarthrosis, and gluteal paralysis appeared in his previous writings. Now after he has supervised the construction of more than 150 of them, he presents the perfected splint in all of its various forms. The use of pressure by an adjustable lever in the correction of scoliosis and foot deformities, an adjustable strap to prevent hip flexion, and ingenious pressure pads are outstanding contributions. The contents will be valuable both to the orthopaedic surgeon and to the brace-maker.

THE TRUE PHYSICIAN. THE MODERN "DOCTOR OF THE OLD SCHOOL". By Wingate M. Johnson, M.D. New York, The Macmillan Co., 1936. $1.75.

This volume contains within a small compass a large amount of valuable and sagacious advice which an older physician might well give to his son or to any other young doctor about to enter the practice of medicine. It is evidently based on the author's experience as a modern doctor of the old school in North Carolina. Among the most interesting of its chapters are those on "Contacts with the Law" and "A Physician's Reading". Anyone might differ with the author in his selection of books, but the point of significance is the importance to every physician of literary contacts and background entirely apart from those of his own profession.

FRACTURES OF BONES AND THEIR TREATMENT. Edited by Prof. V. D. Chaklin. Sverdlovsk, The Ural Institute of Traumatology and Orthopaedics, 1935.

This book comprises 125 pages, and is written by several surgeons from the Ural Institute of Traumatology and Orthopaedics. A description of the simpler methods of treatment for closed fractures of the long bones and mandible is given. It is intended for the practising physician. It is unfortunate that the paper is of rather poor quality and the illustrations correspond to the quality of the paper. This book will be of interest to those American readers who would like to know how fractures are treated in an important industrial center in Soviet Russia.

CALIFORNIA MEDICAL ASSOCIATION CANCER COMMISSION COMMITTEE STUDIES. San Francisco, J. W. Stacey, Inc., 1936. 75 cents.

These studies have appeared separately in *California and Western Medicine* during the past five years and represent very careful investigations by the Committee. The latest opinions about the symptoms and onset, methods of diagnosis, and adequate treatment of early cancer have been collected from the members of the Association and, in many instances, from men outside the State. Emphasis has been laid on the need of cooperation between the surgeon and the radiologist in dealing with the cancer patient.

A Committee on Radiology has reported on the part played by the radiologist in each type of tumor treatment. The surgical treatment has been dealt with by committees on the following subdivisions: Gynecology; Breast; Skin and Mouth; Eye, Ear, Nose, and Throat; Genito-Urinary Tract; Chest; Bone; Connective Tissue and Leukemias; Central Nervous System; Gastro-Intestinal Tract; Thyroid; and Rectum, Anus, and Rectosigmoid.

Where there has been a great difference of opinion between various groups, both sides are presented. Finally, the appendix gives the results of questionnaires submitted to the world's leading cancer specialists on the best treatment of neck glands in cancer of the lip, tongue, and mouth.

PRINCIPLES AND PRACTICE OF RECREATIONAL THERAPY FOR THE MENTALLY ILL. By John Eisele Davis, B.A., M.A. New York, A. S. Barnes and Co., 1936. $3.00.

This monograph is intended as a practical manual for those concerned with the occupational or recreational treatment of various types of mental disorder. It has been prepared by the author in collaboration with Dr. William Rush Dunton, Jr., of the Johns Hopkins University, and has a foreword of introduction by Dr. Adolf Meyer.

The work is based on the authors' experience on the Veterans Administration Faculty at Perry Point, Maryland. After a discussion of types and disease entities, it presents the theory of education and reeducation as the basis of occupational treatment of the insane. It presents a classification of the various motor and psychic activities, the tests which may be applied in determining the value and guiding the application of a variety of formal and informal exercises, and finally it summarizes the aims and objectives of treatment. It has for some time been realized that occupational therapy provides perhaps the most valuable single agent in the palliation and, if possible, rehabilitation of the various mental deviations. This volume summarizes admirably the present status of our knowledge of this important subject and presents it with an explanation of its rational basis and sufficient detail of technical application to make it of value both to the occupational therapist and to the psychiatrist.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Anales (Valencia), III, Núms. 25, 26, 27, 1936.

Anales de Pediatría (Facultad de Medicina de Barcelona), II, Núm. 23, 1935.

Bollettino e Atti della Reale Accademia Medica di Roma, LXI, Fasc. 10–11, 1935.

Bulletin of the National Tuberculosis Association, XXII, Nos. 5, 6, 1936.

Cleveland Clinic Quarterly, III, No. 2, 1936.

Journal of the Indian Medical Association (Calcutta), V, Nos. 7, 8, 1936.

Journal of South Indian Medicine (Madras), II, Nos. 5, 6, 1935.

University of Pennsylvania, Graduate School of Medicine, Announcement for 1936–1937. Philadelphia, 1936.

The Quarterly Bulletin of Sea View Hospital (New York), I, No. 3, 1936.

DIE OPERATIVE BEHANDLUNG DER HABITUELLEN UND PERMANENTEN LUXATIO PATELLAE, IM BESONDEREN NACH KROGIUS UND GOLDTHWAIT (The Operative Treatment of Recurrent and Chronic Dislocation of the Patella, Particularly with Especial Reference to the Operations of Krogius and Goldthwait). O. Kapel. *Acta Chirurg. Scandinavica*, LXXVII, 201, 1935.

WEITERE UNTERSUCHUNGEN ÜBER LUXATIO PATELLAE (Further Studies of Dislocation of the Patella). O. Kapel. *Acta Chirurg. Scandinavica*, LXXVII, 296, 1935.

Follow-up examinations were made on thirty-three patients with forty-two knees upon which operations had been performed. In four unilateral cases the dislocations were chronic. After a variety of operations three of these were cured. One of these cases, that of a congenital dislocation, recurred at once after a Hübscher-Krogius operation. The writer advises against operation in the chronic case if the symptoms are not distressing.

Of the twenty-nine patients upon whom thirty-eight operations for recurrent dislocation of the patella had been performed, four were operated on by a variety of methods with one failure and one fair result. Thirty-four operations were performed as follows: twelve by the Krogius technique; twelve by a combination of the methods of Krogius and Goldthwait; and ten by capsulorrhaphy combined with the technique of Goldthwait.

The cases are reported in detail with the late results. In the ten cases in which the Goldthwait technique was used alone, there were six cures and four failures. The other twenty-four cases, operated upon by the Krogius or combined methods, included one

immediate failure and one poor result without actual redislocation. The other results were good and these two methods are highly recommended.

In a group of fifty-five traumatic dislocations collected from histories in the Copenhagen hospitals, 50 per cent. of the cases were followed by habitual recurrences and 25 per cent. by other difficulties; only 25 per cent. of the patients were without complaint. A complete tear of capsule and synovia was found in three cases operated upon soon after traumatic dislocation. The writer advises primary suture to avoid recurrences. The mechanism of causation is discussed.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

FOUR CASES OF EWING SARCOMA IN RIBS. Hilding Bergstrand. *Am. J. Cancer*, XXVII, 26, May 1936.

The author is convinced that Ewing's sarcoma of the rib is not extremely rare. He reports four cases, all occurring at about the age of puberty. The tumors originated in the sixth and eighth ribs in the back, and tended to grow into the pleural cavity, pushing the pleura ahead of them. They were coarsely lobulated tumors with their greatest length along the ribs. The roentgenograms showed a characteristic increase in density and volume of the ribs, with spicule formation. One of the patients, treated by operation and x-ray, is apparently free from disease over five years after operation, although pulmonary metastases were observed two years after operation. The author points out that this tumor occurs in those parts of the skeleton in which ossification begins toward the end of the second month of foetal life, and suggests that they may derive from the blastema cells of the mesenchyma.

The paper is illustrated with roentgenograms and photomicrographs, and reviews briefly the literature on the histogenesis of these tumors.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

LIPOSARCOMA OF BONE. Donald J. Rehbock and Harry Hauser. *Am. J. Cancer*, XXVII, 37, May 1936.

The authors report two cases of this rare tumor, both of which occurred in elderly patients,—in one instance in the femur and in the other in the ilium. Slow growth and a tendency to develop bone and lymph-node metastases distinguish the tumors from other kinds of primary bone tumor. In one patient there appeared to be definite regression of a bone metastasis in response to x-ray therapy.

The paper is illustrated with photomicrographs and roentgenograms.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

BONE CHANGES OF LEUKAEMIA IN CHILDREN. James M. Baty and Edward C. Vogt. *Am. J. Roentgenol.*, XXXIV, 310, 1935.

The authors state that in most cases of leukaemia the diagnosis is relatively simple, but occasionally the symptoms are atypical and there may be considerable diagnostic difficulty. Aleukaemic leukaemia presents the greatest difficulty. Roentgenographic examination of the skeleton may be helpful in arriving at a correct diagnosis.

During the past six years in sixty cases of leukaemia roentgenograms were made of part or all of the skeleton in forty-three. The discussion is based on the roentgenographic findings.

The most frequent change was the presence of a narrow transverse zone of diminished density just proximal to the metaphysis of the long bones. This zone varied from two to five millimeters in width and was most marked in bones where the growth is rapid. This line was seen in bones of 70 per cent. of the total number of cases. It was present in 80 per cent. of the cases of myeloid leukaemia and in 65 per cent. of the cases of lymphoid leukaemia.—*T. L. Waring, M.D., Iowa City, Iowa.*

WIRBELBRÜCHE UND WIRBELVERRENKUNGEN; BOGENBRÜCHE VOM TYPUS DER SPONDYLOLYSE UND DER SPONDYLOLISTHESE UND IHRE BEDEUTUNG FÜR DIE ERHALTUNG DES RÜCKENMARKES (Fractures of the Vertebral Arches of the Spondylolystic and Spondylolisthetic Types and Their Significance in the Preservation of the Spinal Medulla). L. Böhler. *Chirurg*, VII, 477, 1935.

Most of the German authors believe that spondylolysis or spondylolisthesis always develops on a congenital basis. Most of the American authors explain it as a traumatic lesion. Meyer-Burgdorff thinks the disease is due to a traumatic gibbus with marked lordosis where, by overexertion of the interarticular portion of the fifth lumbar vertebra, a fracture gradually develops leading to spondylolysis. However, Meyer-Burgdorff does not believe that the interarticular portions can be fractured by a single sudden trauma, as they are very strong.

Böhler states that up to the present time there has never been published a series of roentgenograms proving the gradual development of this gliding process. He believes also that besides the spondylolisthesis which develops by itself there exist certain cases in which it is caused by a single sudden trauma. In roentgenograms of patients, as well as in autopsies of recent fractures of the vertebrae, Böhler found fractures of the interarticular portions, with or without gliding, alternating in all vertebrae with the exception of the first, third, fourth, and fifth vertebrae. This is explained by the following fact: In all other vertebrae the interarticular portions are the thinnest parts of the vertebral arches. In the first, third, fourth, and fifth cervical vertebrae, however, the articular processes are perpendicularly posted over each other and the parts between them are especially strong.

The mechanism leading to this fracture is a traumatic effect coming obliquely from backward and above in the direction toward an intervertebral disc. In this case the whole traumatic effect concentrates on the interarticular portion. This becomes fractured and the intervertebral disc is torn, which leads to the gliding of the vertebra. This form of a pure luxation fracture of the real spondylolisthetic type is found in the lumbar vertebrae only. In the upper portion of the spinal column this fracture is generally caused by hyperflexion and a simultaneous shearing effect coming from back and above. In this portion the injury involves a compression of the vertebra with gliding of the vertebra above and a fracture of the intervertebral portions either of the dislocated vertebra or of the one above. If the trauma does not come from the back only, but also from one side, a fracture of only one of the interarticular portions may occur.

In fractures of the lower cervical spine the fracture of the interarticular portion always occurs in the gliding and not in the fractured vertebra. In the case of the second cervical vertebra the fracture mechanism is mostly a hyperextension and here it is very characteristic that from one to two millimeters of the joint surfaces of the superior articular processes remain in connection with the posterior parts of the arches. In the lumbar spine hyperextension is quite frequently the cause of a fracture of the interarticular portion.

The author states that the opinion is quite frequently expressed that the fractures of the arches are the most dangerous, as they develop by a direct trauma to the spinous processes, and the broken arch may by continuation of the trauma be pressed into the spinal medulla. He does not agree with this opinion, as he never saw a fracture of this kind. He believes that it is possible that a direct trauma to the spinous processes may lead to a fracture of the arch and a lesion of the medulla when the fracture occurs not in the intervertebral portions, but in the inferior articular processes. However these cases are rare.

In all fractures of the arches, roentgenograms, as well as autopsies, show that the posterior part of the fractured arch, together with the spinous process, remains posterior to the whole ligamentous apparatus and is kept behind by the inferior articular processes. The corresponding vertebral body, together with the anterior part of the arch, glides forward. Therefore, at the fracture level there is always a widening of the spinal canal and, if the dislocation of the superior part of the spinal column is not too extensive, the

medulla may remain unchanged. In luxations with anterior fractures, however, a narrowing of the spinal canal with compression of the spinal medulla always results. The author concludes, therefore, that fractures of the arches do not as a rule destroy the spinal cord but save it.

Sometimes complete paralysis is found after severe trauma to the cervical spine without any signs of a fracture or luxation of the cervical spine in the roentgenogram. In those cases the sudden severe trauma produces a momentary total luxation of the cervical spine with compression of the medulla, resulting in paralysis. The luxation, however, is immediately spontaneously reduced. There is only a slight sign visible in the roentgenogram,—*i.e.*, the decrease in the height of the intervertebral disc which was torn at the time of luxation.—*Traute Pich, M.D., Iowa City, Iowa.*

KNOCHENCYSTE BEI ENCHONDROM DES FEMUR. RESEKTIONS-PLASTIK. (Bone Cyst in Enchondroma of the Femur. Plastic Resection.) E. Looser. *Deutsche Ztschr. f. Chir.*, CCXLIV, 321, 1935.

The first explanation of the occurrence of bone cysts was given by Virchow, who found cartilaginous tissue in the neighborhood of a cyst in the humerus. Later, however, Virchow's conception was entirely abandoned. Looser has observed a case which proves that Virchow's idea is correct, at least in a small number of cases.

The patient, a male, now nineteen years old, had had a left-sided limp of many years' duration, with weakness of the left leg. The family history was negative. At the age of eleven, a roentgenogram had been taken which showed an irregular bony structure in the proximal end of the femoral diaphysis. Tuberculosis was suspected. Heliotherapy was instituted for a few weeks. One year later, the patient suffered a fracture of the femur while skiing. A roentgenogram showed a pathological fracture through a bone cyst. This fracture healed within ten weeks without shortening. One year later, an incision was made in the cyst wall, and the pathological report was ostitis fibrosa cystica (some islands of cartilage were found in the section). Three years later, the patient was admitted again with pain in the thigh, following forceful strain of the hip region. The roentgenogram showed the bone cyst still present. With the electric saw, a slice of bone, fourteen and one-tenth centimeters long, was removed. A multilocular cystic lesion was encountered, which was surrounded in part by bony tissue and in part by cartilaginous tissue. Half a year later, a fracture occurred through the cystic area. At operation, the upper half of the femur was resected and a tibial bone graft (twenty-three centimeters long, two centimeters wide, and one centimeter thick) was implanted. Solid union had occurred eight months following the operation. One inch of shortening is present, but the patient has good use of the extremity.—*Ernst Freund, M.D., Venice, Florida.*

ÜBER DIE SPONDYLOLISTHESIS. W. Jaeger. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, LII, 107, 1935.

Three factors are of importance for the establishment of a spondylolisthesis: (1) obliquity of the gliding surfaces; (2) separation of the gliding vertebra from its supporting surface, which means a destruction of the caudal intervertebral disc; and (3) changes in the interarticular portion. The term "prespondylolisthesis" should be discarded because it refers only to the first factor and neglects the two others. In some cases, it is all right to speak with Scherb of a "sacrum arcuatum" and "sacrum acutum". If all three factors are demonstrable, but slipping has not yet occurred, one may call the condition "spondylolisthesis imminens".

Jaeger examined 244 spines and found eleven cases of spondylolisthesis and five of spondylolysis. Among these cases were sixty-four certain and eight doubtful fractures of the vertebral bodies, which means that there is one case of spondylolisthesis to every sixteen cases of fracture of the body. Meyer-Burgdorff, therefore, is correct in his statement that spondylolisthesis is frequently associated with pathological conditions at higher levels of the vertebral spine.—*Ernst Freund, M.D., Venice, Florida.*

LATE RESULTS OF THE OPERATIVE TREATMENT OF OSTEO-ARTHRITIS OF THE HIP-JOINT. C. Max Page. *Lancet*, I, 1313, 1935.

After analyzing 112 cases in which operations had been performed during the past five years, the author concludes that of the two procedures—arthrodesis or arthroplasty of the hip joint—arthrodesis gives the best late results. He states that in regard to arthrodesis better technique does give better results; however, the most ingenious arthroplastic procedures may result in a stiff hip while a rough reconstruction operation may produce a freely movable hip. The vascular supply of the parts seems to the author to be the important determining factor.

Of the sixty-nine cases in which arthrodeses were performed, the author reports good results in 70 per cent., moderate results in 17.4 per cent., and bad results in 11.6 per cent. Of the nineteen cases in which arthroplasties were done, good results were obtained in 37 per cent., moderate results in 31 per cent., and poor results in 31 per cent.

The operative procedures used for fusion were resection of part of the head of the femur and resection of part of the acetabulum. An iliac graft was occasionally used. For arthroplasties, the Whitman operation was employed.—*Lewis Cozen, M.D., Iowa City, Iowa.*

BONE CHANGES SIMULATING TUBERCULOSIS OR TUMOUR, WITH SPECIAL REFERENCE TO OSTEOCHONDRITIS. James F. Brailsford. *Lancet*, I, 1487, 1935.

The author discusses the correlation of roentgenographic findings with clinical observations in diseases of bone.

Among the common sources of error, the author includes the mistaking of ossifying periosteal hematomata for periosteal sarcomata. Hematomata, located in the shaft of a metatarsal, may come from very slight trauma. In a few weeks the dorsum of the foot becomes swollen and reddened, and a hard tumor may be palpated. Roentgenographic examination may show a flocculent deposit of calcium around the metatarsal, which has relative osteoporosis. These findings have been known to lead to amputation. If put to rest, the clinical signs disappear and the calcium deposit molds itself around the metatarsal.

In bone tuberculosis, serial roentgenograms are invaluable for watching the progress of the lesion and assisting in the treatment.

Legg-Perthes disease is discussed in relation to the roentgenographic changes. The earliest evidences are (1) an increase in the density of the femoral capital epiphysis; (2) a relative increase in the joint space (as compared with the opposite hip); and (3) osteoporosis of the adjacent extremity of the diaphysis. These changes are found about two months after the onset of symptoms. The dense epiphysis then begins to show signs of compression fracture, followed by the appearance of fragmentation, and the epiphysis is compressed and flattened still more. There is gradual absorption of the dense islands of bone and compression and expansion of the proximal end of the diaphysis. The signs of compression fracture and flattening of the epiphysis are found during the first eighteen months of the disease. After that roentgenograms show a joint outline of a regenerated epiphysis in which the dense fragments are absorbed. Eventually, the last dense nucleus is absorbed and the extremity of the diaphysis shows increased calcium and obliteration of the osteoporotic zone. Signs of regenerated epiphysis and increased calcium in the diaphysis occur during eighteen months to four years after onset and, while these signs are present, the epiphysis remains plastic and can be deformed by pressure; hence the occurrence of permanent deformities if the epiphysis is not protected from the strain of weight-bearing. After four years, the cancellous epiphysis assumes the roentgenographic appearance of normal bone. Although the epiphysis and adjacent diaphysis are compressed, the growth cartilage does not disappear as in an inflammatory process. This is the argument against sepsis or displaced epiphysis as a causative factor. All changes take place within the capsule,—there is apparently an early increase in synovial fluid and a redistribution of calcium in the areas associated with the fluid contents of the

capsule. At first, the epiphysis takes up calcium while the end of the diaphysis loses it; later, in healing, the flow of calcium is in the opposite direction. In contrast to tuberculous arthritis, the healed articular surfaces are smooth, though deformed, and bony ankylosis does not occur because the articular cartilage is not destroyed.

The later development of arthritis, with changes in the acetabulum and head of the femur, is discussed. Statistically, the disease is three times more frequent in males, both sides are about equally affected, and the condition starts commonly between the ages of four and eight years. Clinically, the most common sign is a limp with pain in about 30 per cent. of the cases. Periodic roentgenograms show that the bone remains plastic for an average of over three years. The best results are obtained by early recognition of the disease and immobilization of the femur as long as the head is plastic, even up to four years. Differential diagnosis lies between Perthes' disease and (1) tuberculosis, (2) septic arthritis, (3) endocrine disorders (hypothyroidism), and (4) chondrodystrophies.

The next discussion is Preisser's disease of the carpal scaphoid. This comes on after injury, frequently following the use of a compressed-air drill. There is swelling and tenderness over the scaphoid with stiffness of the wrist. Roentgenograms may be negative, but should be taken in ulnar deviation or with the back of the hand on the film, the skin over the scaphoid being the area of closest contact. Frequently fine fissures are thus seen. Pain subsides after a few weeks, except on extreme hyperextension. Another injury, which may be very slight, brings a recurrence of severe pain and stiffness. Roentgenograms will reveal a cystlike area in the scaphoid with a fissure line through it, or there may be several such areas.

Finally, the author discusses osteochondritis dissecans, a name coined by König. It is found generally between the ages of sixteen and twenty-five and is more common in males. The etiological theory of aseptic necrosis is mentioned, with some thought being given to trauma and subsequent local vascular disturbance of the fragment. Occasionally a surgeon will miss the loose body because it is covered by intact cartilage, which substantiates the idea that the condition is due to a sequestration of a small fragment of subchondral bone. The typical roentgenographic appearance of the lateral surface of the medial condyle of the femur is described.—*Lewis Cozen, M.D., Iowa City, Iowa.*

GOLD TREATMENT OF RHEUMATOID ARTHRITIS. S. J. Hartfall and H. G. Garland. *Lancet*, II, 8, 1935.

The authors report 100 cases which were treated for two years by this method. They obtained excellent results, as evidenced by symptomatic improvement and objective signs, in 70 per cent. of the cases and some improvement in 90 per cent. of the cases. Three deaths occurred, two of which were directly caused by the gold therapy. Crisalbine and gold sodium thiosulphate were injected intravenously in doses of five-hundredths to two-tenths grams weekly until two grams were given. Depending on the progress of the case, two to three or more courses were given, with an interval of at least six weeks between courses.—*Lewis Cozen, M.D., Iowa City, Iowa.*

SOBRE UNA RARA ANOMALÍA VERTEBRAL CONGÉNITA. EL TELESCOPAGE VERTEBRAL. SU DIAGNÓSTICO DIFERENCIAL. (A Rare Congenital Anomaly. Telescoped Vertebra. Its Differential Diagnosis.) José Roberto Abdala. *Prensa méd. Argentina*, XXII, 1807, 1935.

Monstrocities have been studied by pathologists and anatomists, but, because they were considered incompatible with life, the clinician has paid little attention to them. The x-ray, however, introduced a new method of study and many similar lesions which, in the severe form, produced monsters can now be traced, in lesser degrees, in the living.

In 1912 and 1919 Klippel and Feil published their description of the congenital reduction in number and fusion of cervical vertebrae. The term "vertebral telescopage" was suggested by Bar in 1903 to describe what he thought happened in foetal life,—a telescoping of the vertebrae by some traumatic action. The infant whose case he re-

ported apparently had no neck; the ears appeared lower than normal, the trunk shortened. Roentgenographic examination showed the lower cervical vertebrae reduced to small osseous nodules fused together. Anomalies of the ribs were also present.

The author believes that the term "Klippel-Feil syndrome" should be used only for the short neck due to reduction in number of the cervical vertebrae.

The various theories of pathogenesis are discussed. Emotional shock, self-attempted abortions, chemicals, toxins, and infections are among the possible etiological factors. Inasmuch as the centers of ossification of cervical vertebrae do not appear until the third to fourth month, while those below begin in forty to fifty days, this would explain why severe trauma, such as violent uterine contractions produced by attempts to produce abortion, would cause a collapse of the lower cervical vertebrae.—*G. Mosser Taylor, M.D., Iowa City, Iowa.*

Ostéite fibreuse déformante de Paget et sarcome (Osteitis Deformans and Sarcoma). P. Banzet, J. Delarue, and A. Elbim. *Presse Méd.*, XLIII, 1842, 1935.

On the basis of a case which they observed in which sarcoma developed in a patient suffering from Paget's disease, the authors review some of the literature on this subject. They call attention to the fact that true sarcomata are apparently rare. They point out that some confusion may have arisen from the fact that the "brown tumors", which consist of myeloplaxes and which form part of the histological picture of von Recklinghausen's fibrocystic osteodystrophy, have been mistaken for true sarcomata. They do not believe that the tissue degenerates into sarcoma, but that a sarcoma develops as a true new growth in a bone already the site of the changes characteristic of Paget's disease. They note the greater tendency toward fracture in cases of sarcoma as compared with the uncomplicated cases of Paget's disease.—*Henry Milch, M.D., New York, N. Y.*

Le "forage médical" de la hanche ("Medical Forage" in the Treatment of Arthritis of the Hip). F. Coste and J. Fauvet. *Presse Méd.*, XLIII, 2002, 1935.

Since the action of surgical drilling of the neck of the femur is to increase the blood supply of the arthritic hip, the authors use the term "medical forage" in the sense that it produces an increase in the blood supply by medical means. The procedure which they describe consists in the periarticular injection of histamine bihydrochlorate. The injection is begun with a dosage of one-half a milligram to one milligram. Further details of the treatment are not given.

The authors report twelve cases in which an average of six injections seem to have yielded marked amelioration of the pain. However, they note eight other cases, apparently similar to the first twelve, in which the results were not satisfactory. They cannot account for the variation in the results. They suggest that the method be given trial because one can tell after one or two injections whether there is any possibility of success. Where there is no immediate response, the method should be discontinued.—*Henry Milch, M.D., New York, N. Y.*

Ostéite déformante de Paget et traumatisme (Paget's Osteitis Deformans and Trauma). J. A. Lièvre. *Presse Méd.*, XLIV, 45, Jan. 8, 1936.

The author reports three cases and calls attention to the literature on the subject of localized Paget's disease. He notes that, while other bones—*e.g.*, the femur—may be attacked, the tibia is most commonly the site of the localized Paget's disease. The disease usually begins after an injury and is characterized by a latent interval between the injury and the onset of symptoms. Clinically, roentgenographically, and pathologically, the specimens resemble those seen in the diffuse type of Paget's disease.—*Henry Milch, M.D., New York, N. Y.*

A PROPOS DU TRAITEMENT DE L'ÉPICONDYLITE DES JOUEURS DE TENNIS (Treatment of the Epicondylitis of Tennis Players). L. Tavernier. *Presse Méd.*, XLIV, 99, Jan. 15, 1936.

With reference to Massart's suggestion for the local injection of novocain in the treatment of epicondylitis, Tavernier states that his results from this method have been completely unsatisfactory. In his opinion, mere scraping of the epicondyle with detachment of the muscles is a simple and safe procedure.—*Henry Milch, M.D., New York, N. Y.*

A PROPOS DU TRAITEMENT PAR INFILTRATION NOVOCAÏNIQUE DE L'ÉPICONDYLITE DES JOUEURS DE TENNIS, DES MALADIES POST-TRAUMATIQUES DE MÊME ORDRE, DES SOI-DISANT APOPHYSITES DE CROISSANCE, DE CERTAINES FRACTURES SANS DÉPLACEMENT ET DES SÉQUELLES OSTÉO-ARTICULAIRES (Treatment by Novocain Infiltration of the Epicondylitis of Tennis Players, of Post-Traumatic Disorders of the Same Type, of the So Called Apophysitis of Growth, of Certain Fractures without Displacement, and of Osteo-Articular Sequelae). René Leriche. *Presse Méd.*, XLIV, 99, Jan. 15, 1936.

Leriche disagrees with Tavernier and is in complete accord with Massart in the treatment of epicondylitis. He goes even farther and states that novocain infiltration is of great value in treating all post-traumatic juxta-epiphyseal pain. This method should be used in the treatment of epiphysitis during growth, in the foot, the hand, the elbow, and the shoulder, and in the treatment of all sequelae of articular fractures.—*Henry Milch, M.D., New York, N. Y.*

APROPOS DE TRAITEMENT DES FRACTURES DES CONDYLES MAXILLAIRES (Treatment of Maxillary Condyles). L. Lebourg. *Presse Méd.*, XLIV, 360, March 4, 1936.

Fracture of the condylar neck of the maxilla in the adult is usually best treated by immobilization. In the younger subject immobilization may be dangerous in that it may lead to ankylosis of the jaw. To prevent this, the author recommends the application of elastic traction. This permits adequate alignment of the fragments and, while maintaining reduction, allows motion of the mandible.

Traction is applied by means of rubber bands fixed to the canine teeth and to a resistant wire which is so placed as to form a perifacial arc about one inch distant from the arch of the mandible. The ends are fixed to a plaster fillet which encircles the forehead. This permits downward and forward traction of the large mandibular fragment and makes arthrotomy for the small condylar fragment unnecessary.—*Henry Milch, M.D., New York, N. Y.*

NODULES SOUS-CUTANÉS CHEZ LES RHUMATISANTS CHRONIQUES. LIPOMATOSE NODULAIRE. (Subcutaneous Nodules in Chronic Rheumatic Patients. Nodular Lipomatosis.) Pr. Merklen, R. Waitz, and J. Warter. *Presse Méd.*, XLIV, 473, March 21, 1936.

The authors note that true rheumatic subcutaneous nodules are to be distinguished from a nodular lipomatosis. They report three cases in which patients suffering from a chronic rheumatic condition were affected with histologically established diffuse nodular lipomatosis. These nodules are differentiated from the rheumatic nodules by the facts that they are located at some distance from the joints, they are painful to the touch, and histologically they are true encapsulated lipomata and not degenerated rheumatic nodules.—*Henry Milch, M.D., New York, N. Y.*

RARÉFACTION OSSEUSE POST-TRAUMATIQUE (Post-Traumatic Rarefaction of Bone). Jean Baumgartner and Francis Berthoud. *Presse Méd.*, XLIV, 495, March 21, 1936.

Attention is called to the fact that, since the work of Leriche, the osseous system has come to be considered as a large reservoir of readily mobilizable calcium. Osteoporosis, the evidence of this mobilization of calcium, is the result of a prolonged hyperaemia, due to vasomotor imbalance which may be caused by traumatism or infection. The exact mechanism of the prolonged action of trauma has not been explained, except upon the basis of a vasomotor instability. In this connection, the authors report the case of a young woman who had been subjected to bilateral oophorectomy eight years before the onset of trouble in the ankle and knee joints. The roentgenograms, which were examined by Leriche himself, suggested a post-traumatic osteoporosis with fracture. In view of the earlier operative intervention, homovarine (Byla) and tricalcine were given hypodermically daily, and later at longer intervals, for a period of three months. The disappearance of the lacunar defects under this therapy led the authors to the opinion that trauma plays a secondary or precipitating rôle in the development of osteoporosis, while the primary rôle is taken by some endocrine disturbance. They call attention to a communication by Leriche, who suggested injections of ovarian extract in the treatment of traumatic osteoporosis of the knee.—*Henry Milch, M.D., New York, N. Y.*

INJECTIONS INTRA-ARTÉRIELLES D'ANTISEPTIQUES DANS LES INFECTIONS DES MEMBRES (Intra-Arterial Antiseptic Injections in Infections of the Extremities). G. Arnulf and Ph. Frieh. *Presse Méd.*, XLIV, 629, Apr. 15, 1936.

The authors call attention to the fact that intra-arterial injections are indicated in severe lymphangitis, wet gangrene of the extremities (especially of arthritics), suppurative arthritides (including the gonorrhoeal variety), suppuration of the extremities (including abscess, osteomyelitis, etc.), gas gangrene, and tropical ulcers. For the most part, the results are only moderately successful in any condition except the lymphangitides in which they are particularly satisfactory.

The authors especially point out that the intravenous method is not to be used except as recommended by Leriche in cases of staphylococcus infection where gentian violet appears to have specific effect. Otherwise, a 2-per-cent. aqueous solution of mercurochrome is injected into the artery. The artery may be punctured subcutaneously by a spinal-puncture needle, eight centimeters long, with a short, sharp bevel, or it may be exposed by incision and then punctured. Eight to ten cubic centimeters of solution is injected,—never more, since larger amounts may result in liver and kidney disturbances. Occasionally two, three, or four injections may be undertaken. The indication of a satisfactory injection is the discoloration of the skin and a thermal rise on the day following the injection. The contra-indications are age, albuminuria, and vasomotor disturbances of the extremities. For the lower extremity, the injection is made into the femoral artery; for the upper extremity, into the subclavian artery or into the brachial artery at the elbow.

The authors enumerate some fourteen cases in which this therapy was undertaken with improvement. When the improvement is noted, it is apparent after one or, at most, two injections. If no improvement is noted, the usual surgical procedures are to be undertaken.—*Henry Milch, M.D., New York, N. Y.*

LA RÉDUCTION DES FRACTURES DU COTYLE AVEC PÉNÉTRATION INTRA-PELVIENNE DE LA TÊTE FÉMORALE (Reduction of Central Fractures of the Acetabulum with Intrapelvic Penetration of the Femoral Head). P. Moiroud. *Presse Méd.*, XLIV, 748, May 6, 1936.

Apart from the question of reduction by means of traction in the axis of the shaft of the femur and in the axis of the neck of the femur, the author calls attention to the prognosis of such injuries. Even when the fracture was properly reduced, Cottalorda in 1922

noted ankylosis following this injury in about 40 per cent. of the cases. Where this does not occur, there may be limitation in function due to the fact that the head of the femur seems to atrophy, not only in consequence of the injury, but also as a result of trophic disturbances. Therefore, the question of therapeutic fusion of the hip should be considered in all cases of this type of injury.—*Henry Milch, M.D., New York, N. Y.*

THE INFLUENCE OF THE THYROID GLAND ON THE NATURE OF BONE CALLUS. I. A. Shtshervina. *Soviet Surg.*, X, 29, 1935.

A series of experiments on rats were undertaken with the purpose of establishing the influence of the thyroid-gland secretion on the physical properties of callus. The resistance to tension, strain, and compression was investigated. The following were the conclusions reached:

The removal of the thyroid gland retards regeneration of bone. Newly formed bone is less resistant. Transplantation of the thyroid gland shortens the time of regeneration and makes the regenerated bone more resistant, approaching the strength of bone in control animals. The transplantation of the thyroid gland with a simultaneous transplantation of cartilage under the skin produces a callus equal in strength to, and even surpassing, callus in control animals. These results require further clinical investigations.—*Emanuel Kaplan, M.D., New York, N. Y.*

NEW METHODS OF LEG AMPUTATION. G. A. Reinberg and A. V. Kaplan. *Soviet Surg.*, XII, 65, 1935.

To avoid the usual postoperative complications of leg amputation a new method is suggested. Based on cadaver study, it gave apparently satisfactory results in nineteen cases in which operations were performed by seven surgeons.

An anterior skin flap is dissected out, its base being wider than the half of the circumference of the leg and its length more than the diameter of the leg. A horizontal skin incision unites the proximal ends of the flap posteriorly. The skin in the back is separated from the soleus. The Achilles tendon is cut from above downward and from the back forward. The triceps surae is separated from the bones of the leg to the level of amputation. The bones are sawed through and smoothed out. Two flaps are thus formed: an anterior skin flap and a posterior musculo-aponeurotic flap. The muscular flap is united to the periosteum of the tibia in front, and the skin flap is attached to the skin of the back of the leg.—*Emanuel Kaplan, M.D., New York, N. Y.*

INJURIES TO THE CRUCIAL LIGAMENTS OF THE KNEE JOINT. Henry Milch. *Soviet Surg.*, X, 101, 1935.

After a thorough analysis of the physiology of knee motion and the rôle played by the crucial ligaments in this motion, the author gives a historical description of the surgical treatment of injuries to the crucial ligaments and a critical analysis of these operations. Citing examples from an extensive literature and basing his conclusions on his personal experience, the author finds that the importance of the crucial injuries is exaggerated, and that the chief offender in the loss of stability in knee injuries is the medial collateral ligament. The presence of an extensive tear of the crucial ligaments does not require their surgical restoration. The repair of the medial collateral ligament, which may be torn in early cases or weakened in old cases, is all important. The repair is accomplished by a restoration of this ligament with a fascia-lata transplant.—*Emanuel Kaplan, M.D., New York, N. Y.*